CDC Z4R051

Diagnostic Imaging Journeyman

Volume 1. Department Administration and Infection Control

Air Force Career Development Academy

The Air University

Air Education and Training Command

Z4R051 01 0316, Edit Code 03

AFSC 4R051

Author: MSgt Joel Hermesch
MSgt Christopher Gomien
Medical Education and Training Campus (METC)
937th Training Group (AETC)
382 TRS/TRR
3068 William Hardy Road, Bldg 899
JBSA Fort Sam Houston, TX 78234–7521
DSN: DSN 420-1643
E-mail address: christopher.m.gomien.mil@mail.mil

Instructional Systems Specialist: Gary McLean

Editor: Carrie Rodgers

Air Force Career Development Academy (AFCDA)
The Air University (AETC)
Maxwell-Gunter Air Force Base, Alabama 36114–5643

Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

ENTRY INTO this 5-level career development course marks the beginning of a new phase of your education as an Air Force radiologic technologist. During your 3-level training, you worked toward attaining basic proficiency in the technical aspects of this career field. This course will help you master the knowledge and skills needed to perform as a fully independent diagnostic imaging journeyman. As such it covers not only the technical aspects of radiologic technology but also information pertaining to the administrative functions vital to any diagnostic imaging department.

This Career Development Course (CDC) Z4R051, *Diagnostic Imaging Journeyman—Department Administration and Infection Control*, has five volumes, each devoted to a different aspect of our profession. This first volume contains information relating to department administrative procedures and infection control. Unit 1 covers professionalism and the legal and ethical aspects of radiology. Unit 2 discusses infection control in the medical treatment facility environment. Unit 3 deals with film library functions and property management procedures. Unit 4 completes this volume by talking about the role of quality management.

The remaining four volumes in this course are devoted to the technical aspects of Diagnostic Imaging with accompanying discussions on anatomy and physiology. Volume 2 presents a thorough study of the fundamentals of radiologic science and deals with radiation physics, radiobiology, and the controlled production of X-rays for imaging the body. Volume 3 contains detailed information on osteology and routine radiographic positioning. Volume 4 covers digital imaging concepts and special aspects of clinical imaging like fluoroscopy, mobile radiography, bone densitometry, mammography, and computed tomography. Volume 5 wraps up the course with information on radiographic contrast media and the procedures that use contrast agents to image various structures of the body.

A thorough and dedicated study of the information in this course will help prepare you for the end of course examination, promotion testing for staff sergeant through master sergeant, and the American Registry of Radiologic Technologists examination. The effort you put forth in learning the information presented in this course may be the single most critical factor in the success of your career in the Air Force and in diagnostic imaging. Manage your time wisely throughout the duration of this course and, of course, good luck!

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

The use of a name of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by the Air Force.

To get a response to your questions concerning subject matter in this course, or to point out technical errors in the text, unit review exercises, or course examination, call or write the author using the contact information on the inside front cover of this volume.

NOTE: Do not use the IDEA Program to submit corrections for printing or typographical errors.

If you have questions that your supervisor, training manager, or education/training office cannot answer regarding course enrollment, course material, or administrative issues, please contact Air University Educational Support Services at http://www.aueducationsupport.com. Be sure your request includes your name, the last four digits of your social security number, address, and course/volume number.

This volume is valued at 12 hours and 4 points.

ACKNOWLEDGMENTS

PREPARATION of this volume was aided through the cooperation and courtesy the American Registry of Radiologic Technologists. Materials contained in unit 1 are reproduced by permission from the American Registry of Radiologic Technologists. Permission to use this information is gratefully acknowledged.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Unit 1. Professionalism, Legal, and Ethical Aspects of Radiology

PATIENTS come to Diagnostic Imaging (DI) when they are not feeling their best and, because of how they are feeling, patients may act rude or disrespectful towards you. Though it is not nice of the patients to act that way, how you react is what is important. Whether talking about being in the military or working in DI, both are professions and you are expected to always maintain your professionalism (or military bearing). How you interact with patients, fellow DI staff, and other medical staff in your facility is a reflection of you, your imaging department, and of course, the USAF. In this unit section one discusses professionalism and protection of patient information, while section two lays out some important legal and ethical issues to consider and be aware of in medical imaging.

1–1. Professionalism and Protection of Patient Information

Throughout your daily imaging activities, you interact with patients, fellow medical staff members, and view protected patient information. It is important to always treat people with respect and speak to them in a courteous manner, showing compassion when appropriate. In addition you have access to protected patient information to perform the job competently. Protecting patient information is imperative and understanding privacy rules is required. In this section the discussion will include considerations for professional interaction and protections for safeguarding patient information.

001. Professional interaction considerations

Stop and think for a minute, what does "act professional" mean to you? Your answer to that question will quite possibly be based upon your cultural upbringing and life experiences. Cultural differences (diversity) in the workplace definitely affect how professionals act and are received by others. Therefore, before looking at communication skills, let's look briefly at how cultural diversity affects the professional environment.

Respect for cultural diversity

Depending upon the resource, cultural diversity can be interpreted in many ways. One definition of *culture* states that it is the behaviors and beliefs characteristic of a specific social, ethnic, or age group. *Diversity* is known as the state of difference or variety. Cultural diversity, therefore, is the variety of behaviors and beliefs that exist among people from different social and ethnic backgrounds or age groups. Cultural beliefs affect how people live their lives and, in turn, how people view healthcare and the need for care. If cultural differences are not respected, medical professionals (including you) may find it difficult to communicate and provide care for sick individuals. While cultural diversity may pose some issues in the medical setting, it also creates the potential for more widespread growth and acceptance in providing quality healthcare.

Now let's revisit what it means to "act professional." According to the Merriam-Webster's dictionary, professionalism is "having or showing the skill, good judgment, and polite behavior that are expected from a person who is trained to do a job well." As a DI technologist, you are a professional working in a professional field. It is very important that you conduct yourself in a manner that is viewed as respectful to the various groups of people you interact with. Whether you are interacting with a medical staff member from outside of DI or a patient, you must always act professionally.

Showing respect for a person's beliefs and culture will improve relations with them, which will, in turn, increase your ability to provide them the highest in quality healthcare while visiting the DI department. You must be attentive to the behaviors of different groups of people and to how they view some basic mannerisms. For example eye contact, how close you stand to another person, the volume of your voice, gestures, and touch are all mannerisms that may potentially have different meanings from culture to culture.

Communication technique considerations

Poor communication is the *most* often filed complaint by a patient or visiting medical staff member (physician, nurse, or medical technician). Communication in its most basic form is the exchange of information from one person to another. Nonverbal and verbal are two forms of communication we need to discuss.

Nonverbal communication

Considering that what you say to a patient is the primary means of communication, it is important that your nonverbal communication behaviors are supporting the words you speak. Nonverbal communication accounts for up to 55 percent of human communication by means of gestures, posture, facial expressions, touching, or eye contact. How you communicate nonverbally is typically a representation of how you were raised culturally. You should be aware of your own nonverbal messages to gain adequate trust and acceptance from your patient when communicating with them. For example eye contact in the United States is a welcomed, positive behavior, whereas in other cultures, eye contact is simply not acceptable. The same goes for touching; placing your hand on a patient's shoulder may seem okay to you because you may be trying to convey a feeling of reassurance or support. In other cultures, though, it could be interpreted as a form of dominance. If you must touch patients, it is always best to tell them in advance what you are going to do first so not to inadvertently offend them or make them feel uncomfortable.

Verbal communication

Verbal communication uses language to convey your message. When using language to explain a DI exam to a patient, you must use words appropriate to your listener. For example if explaining a radiographic procedure to a retired physician, you could be quite technical and use medical terms in your explanation; if talking to a person that doesn't have medical training, you would probably need to use more basic terms to explain the same procedure. Being a good verbal communicator means you speak clearly and distinctly, while choosing appropriate words your patient will understand. Speak face-to-face so your patient can make eye contact (if they so desire) and see your expressions. Interacting with people in this way shows them they have your full attention while also allowing you to see any nonverbal messages as you speak to them. Always pay attention to your patient when communicating with them and be willing to modify your approach if you find your first method doesn't seem well received.

Listening skills

One of the *most* important parts of good communication is effective listening. The skill of listening involves being patient enough to not interrupt a person when he or she is speaking while also giving your full undivided attention. Patients often give subtle messages as to what they are feeling; it is important to pay close attention to what is stated while not rushing to get on to the next question, exam, or patient on the schedule.

Patient interaction

All patient interaction should be on the professional level. Patients should consistently be addressed properly by their rank and last name or Mr./Mrs./Ms. and their last name. Common courtesies of "please", "thank you", and "you're welcome" are expected whenever addressing a patient. Patients have a right to privacy and must be offered a gown anytime an exam requires the removal of clothing. If performing an exam on a patient of the opposite sex, which requires private body parts to be

uncovered, make sure a chaperone is present during the examination (or anytime at the patient's request). At no time is it appropriate to ask for personal information from the patient who does not pertain to the procedure or reason for his or her visit to the DI department.

Medical staff interaction

Other medical staff members bring emergency room and inpatients to DI. It is possible these staff members are under stress just as you may be. Always show respect and patience with fellow medical staff members as they are doing their best to provide the utmost in patient care just as you are. If disagreements or confrontations arise, take the discussion away from the patient if possible or delay the conversation to a later time when the patient is not around. Remember, you are a service-oriented professional; therefore, patients and staff members will come and go—make sure their time in DI is a pleasant experience.

002. Patient information and privacy

Medical records, whether electronic or paper, are considered personal identifiable information (PII) and must not be released or shared with unauthorized personnel or entities. Protection of patient's PII is another important task of radiographers.

Medical records

The medical record is the official record of medical diagnosis and treatment for the patient. A properly documented medical record is vital in ensuring continuity of care for the patient. In addition it may be used as a record for legal proceedings. Traditionally, documenting the medical record has been the domain of physicians and nurses; however, in certain situations radiographers are responsible for making entries as well.

The specific requirements for documenting medical imaging procedures will vary from facility to facility, but there are several areas that may be addressed including: appropriate clinical history (reason for the exam), patient vital signs during the procedure, technical aspects of the procedure (exposure technique, number of images, fluoroscopic time, etc.), the amount and type of contrast media administered, and any postprocedural patient instructions. Familiarize yourself with your facility's requirements before attempting to document a patient's medical records.

Whenever making entries in a patient's medical record, only record the pertinent facts. Avoid opinionated statements, such as "the patient was a jerk," in favor of factual statements, such as "the patient appeared agitated." Using factual, professional language should help avoid a defamation suit.

Privacy Act

The Privacy Act of 1974 was enacted because congressional leaders determined that individual privacy was directly affected by the collection, maintenance, use, and dissemination of personal information by federal agencies. The Privacy Act is meant to *protect* individuals' right to privacy as it relates to information kept in a system of records by the federal government. Information contained in patient medical records and patient information kept in hospital computer systems are protected under the Privacy Act.

In effect the Privacy Act restricts personnel who maintain a system of records from releasing information contained in those records to unauthorized individuals. Generally hospital personnel are authorized access to patient records but *only* in the performance of their duties. You may not, for instance, pull your neighbor's medical records to find out why he or she was seen in Internal Medicine last week or look up a colleague's lab results. *Disclosure* is the transfer of information from a system of records by any means of communication to organizations or individuals other than the subject or an agent acting for the subject. Those who are responsible for protecting records will not disclose any record to anyone other than to the subject, except when ordered to do so by a court or when authorized under the Freedom of Information Act. For example you may *not* release a husband's record to his wife or an adult child's record to a parent *without* a valid power of attorney

authorizing that person access to the record. When in doubt as to whether or not you should release medical records, contact your facility's legal consultant.

As a radiographer, you have a requirement to complete initial and annual privacy act training to ensure you are aware of the rules of behavior for handling PII and consequences when privacy act rules are not followed. PII is considered any information that can be used to distinguish a person's identity, such as (but not limited to) a person's name, social security number (SSN), date and place of birth, and mother's maiden name. In addition medical, educational, financial, and employment information are also considered PII and must be protected.

Social media

Social media presents a unique challenge to the radiographer's responsibility to protect patient information. Radiographers often encounter interesting studies that they may be tempted to share on the internet via Facebook, Twitter, or Instagram; however, in doing so, radiographers are violating a patient's right to privacy. Even radiographic images posted on the internet that include no specific patient information (name, date of birth, SSN, etc.) can possibly be linked to a patient and violate privacy rules if the individual sharing the image(s) also shares unique details about the study or states the imaging location.

While social media is a fun and fast way to communicate with friends and colleagues around the globe, you are expected to take the ethical highroad and refrain from posting (sharing) any patient information, radiographic images, or exam videos on social media websites.

Electronic transmission of patient information

There are three things to consider before sending an electronic message (e-mail) with patient information or PII included in the message:

1. Is the PII or private patient information necessary to the message?
2. Does the recipient have a right to know the PII or specific patient information?
3. Do you have permission to release the PII or patient information?

When using e-mail to transmit PII or patient information, you must *encrypt* the message and add the following:

1. In the subject line, add "For Official Use Only" ("FOUO") to the beginning of the entry.
2. Include the following statement at the beginning of the e-mail:

   "This e-mail contains FOR OFFICIAL USE ONLY (FOUO) information which must be protected under the Freedom of Information Act (5 U.S.C 552) and/or the Privacy Act of 1974 (5 U.S.C. 552a). Unauthorized disclosure or misuse of this PERSONAL INFORMATION may result in disciplinary action, criminal and/or civil penalties. Further distribution is prohibited without the approval of the author of this message unless the recipient has a need to know in the performance of official duties. If you have received this message in error, please notify the sender and delete all copies of this message."

Do *not* indiscriminately apply this statement to all e-mails. Use it only in situations when you are actually transmitting protected personal information.

Social security number reduction plan

The purpose of the SSN reduction plan is to reduce or eliminate the use of SSNs in DOD and AF record systems. In reference to this plan, even your military identification card (or common access card) no longer displays your SSN. Instead, a Department of Defense (DOD) identification number is assigned and included on the back of your card. When patients check-in for their imaging procedure, this DOD number is now used to access patients' information in your hospital information system

(computerized record and retrieval system). DOD identification numbers should be protected the same as a SSN.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

001. Professional interactions considerations

1. What is cultural diversity?

2. What is the *most* often filed compliant by a patient or visiting medical staff member?

3. Nonverbal communication accounts for up to how much of human communication?

4. What are some examples of nonverbal communication behaviors?

5. How should patients be addressed?

002. Patient information and privacy

1. What a medical record?

2. What is the Privacy Act meant to do?

3. What does the term *disclosure* mean in reference to a system of records?

4. Under what circumstances may you release a husband’s medical record to his wife?

5. What is personal identifiable information (PII)? List examples.

6. What are three things to consider before sending an electronic message (e-mail) with patient information or PII included in the message?

7. What is the purpose of the social security number (SSN) reduction plan?

1–2. Legal and Ethical Aspects of Diagnostic Imaging

Legal issues are an important yet often overlooked aspect of medical imaging, especially in the military; however, litigation involving imaging professionals, including technologists, is on the rise. Many of us tend to feel that we are somehow shielded from litigation because we are in the Air Force. Yet the adage "you can sue anyone for anything" has been put to the test successfully with increasing frequency and fervor in our litigious society. In addition advances in medical science have made once clear ethical boundaries increasingly fuzzy. Almost daily health care professionals are faced with a myriad of ethical dilemmas, and the field of imaging is no exception. For these reasons we have included this section on the legal and ethical aspects of medical imaging to familiarize you with some of the more pertinent issues faced in the day-to-day DI environment.

003. Ethical considerations in Diagnostic Imaging

The term *ethics* has many shades of meaning. Perhaps the one most appropriate for our discussion is a code of morals of a particular group or profession. Ethics is what we use in our daily activities to help us determine right from wrong in instances when the law does not define the answer clearly. For instance, we use our professional judgment to decide if a radiograph meets acceptable standards of quality or if it should be repeated; however, at 1630, on a Friday afternoon, it often becomes as much an ethical decision as one of professional judgment.

The health care profession is and should always be a patient-centered environment. The decisions we make in the performance of our duties can have significant impact on the quality of life of the individuals for whom we care. With this in mind, the American Registry of Radiologic Technologists (ARRT) has developed the *Code of Ethics for Radiologic Technologists* to guide those working in our profession.

Ethics versus morals

Before diving into the ethical principles for radiologic (or DI) technologists, it is necessary to lay out the subtle differences between ethics and morals. *Morals* describe one's own principles regarding right and wrong. While morals may be influenced by an individual's culture or society, they are personal "rules" created and followed by the individual himself or herself. *Ethics* are external standards created by institutions, clubs, or professions. Ethical standards are a set of rules laid out for a social system or profession regarding what is considered acceptable behavior. Though both terms represent right versus wrong conduct, morals are personal rules versus ethics are rules of a profession.

As a DI technologist, your most important ethical concern is to always protect the rights of your patient. Below is a list of key components used to create most facilities' Patient's Bill of Rights, which ensures patients have the right to:

- Considerate and respectful care—this is self-explanatory.
- Information; yes, the patient has a right to information, but you are not obligated to give information when it is requested. A good example is when your patient asks you what you saw on his or her radiograph; as a DI tech, you are not authorized to give the patient your interpretation of what you see on his or her radiograph.
- Privacy and confidentiality; the right to privacy means the patient's modesty and dignity will be respected. Confidentiality means a patient's financial and medical information cannot be released without his or her written permission.
- Genetic information; patients are given the right to allow or not allow their biological information to be used with the health treatment or anonymous genetic research cases.

- Informed consent; a patient's permission is required for any procedure that involves high risk or experimentation.
- Refuse treatment (or an examination); straightforward, if patients decides they do not want the treatment or examination to be performed on them, you must comply.
- Dignity when dying; simply stated, the patient has the right to pass away with respect to his or her own wishes/beliefs. This right ventures into the realm of "do not resuscitate/intubate" (DNR/DNI) or "advanced directive" orders.

Ethical principles

The code of ethics for our profession is based on several ethical principles recognized by our society as applying to health care delivery. Among these are the principles of autonomy, nonmaleficence, beneficence, and fidelity.

Autonomy

The principle of *autonomy* means each individual has the right to determine the course of his or her own health care. Closely associated with the principle of autonomy is the basic right of self-determination, which means individuals should be allowed to control what happens to their own bodies.

To place this in concrete terms, we cannot force a person to have a medical procedure he or she does not wish to have. As a technologist, you should always ensure the patient has received enough information about a procedure to permit the patient to make an intelligent decision about having the procedure before proceeding. This can involve answering any questions the patient may have that are within your realm of expertise or informing the physician of the patient's concerns so that the physician may address them. The only time the principle of autonomy should be bypassed is in life-threatening emergencies where the patient is incapacitated and unable to provide consent or in instances where the patient is incapable of providing consent and the parent or legal guardian does so.

Nonmaleficence

The principle of *nonmaleficence* means to do no evil or harm. This principle requires no action to prevent harm; it simply requires that we do nothing that would harm the patient, such as intentionally administering the wrong medication or contrast medium. While at first consideration this concept seems very straightforward, it can lead to ethical dilemmas in situations where doing nothing will actually cause harm to the patient, but the patient adamantly refuses to be treated.

Beneficence

The principle of *beneficence* means to do good and prevent harm. The primary difference between this principle and the principle of nonmaleficence is that beneficence *requires action*. Performing the repeat radiograph at 1630 on Friday afternoon when you would rather be on your way out the door to start your weekend requires a degree of beneficence to do what is good for the patient.

Fidelity

The principle of *fidelity* means to strictly observe duties and meet the reasonable expectations of patients regarding professional service. In other words a person has a right to expect a certain degree of service from any professional (radiographers included) who has a duty to that individual. In health care the legal basis for reasonable expectations is based on the accepted standard of care for the profession. You have a duty to perform your job to the level of competency that is generally possessed by other radiographers.

Code of Ethics

Based on these and other ethical principles, *all* registered radiographers must adhere to the ARRT's *Code of Ethics*. At this point in your career, you are not a registered radiographer; however, since you are practicing the profession, adherence to the code of ethics is the standard to which you will be

measured. If you are called to defend your actions while performing your radiography duties, you will be held responsible against these standards.

The code consists of 10 principles, which are listed in the table below. Read them carefully so that you may comply with the spirit in which the code was written. *"The ARRT Standards of Ethics are reprinted by permission of the ARRT. The ARRT Standards of Ethics are copyrighted by the ARRT."*

Principle		
Number	**Text**	**Discussion**
One	The radiologic technologist acts in a professional manner, responds to patient needs, and supports colleagues and associates in providing quality patient care.	The driving concept behind this first principle is professionalism—in both appearance and attitude. Each of these factors is critical in obtaining confidence and trust from patients and coworkers.
Two	The radiologic technologist acts to advance the principle objective of the profession to provide services to humanity with full respect for the dignity of mankind.	Always remember that your patients are people, not units of work that must be accomplished. Fully address any questions or concerns they may have and always respect their modesty and privacy.
Three	The radiologic technologist delivers patient care and service unrestricted by the concerns of personal attributes or the nature of the disease or illness, and without discrimination on the basis of sex, race, creed, religion, or socio-economic status.	We in the military must perform our duties free from discrimination based on sex, race, creed, religion, or socioeconomic status. However, perhaps less clear is our responsibility to care for patients regardless of the nature of disease or illness. We have all encountered patients whose physical condition was repulsive. It is a natural human reaction to recoil from disease (i.e., AIDS or Ebola), but as health care professionals it is our duty to care for the sick regardless of the nature of their disease. Imagine yourself or a parent in the patient's place and act accordingly.
Four	The radiologic technologist practices technology founded upon theoretical knowledge and concepts, uses equipment and accessories consistent with the purposes for which they were designed, and employs procedures and techniques appropriately.	This principle calls for technologists to obtain and maintain technical competency. Never perform a procedure or operate a piece of equipment for which you have not been fully trained by a competent authority. In addition technologists must strive to keep pace with ever advancing technology and the changes in practice that accompany these advances. Just because you learned to perform a procedure a certain way 5 or 10 years ago while you were in training does not mean that technique necessarily meets the current standard of care.
Five	The radiologic technologist assesses situations; exercises care, discretion and judgment; assumes responsibilities for professional decisions; and acts in the best interest of the patient.	Contrary to popular belief outside our career field, DI technologists are not "button pushers." We are trained professionals who possess a high degree of knowledge and skill in diagnostic medical imaging. As such, we must take responsibility for our behavior and the decisions we make in the course of our duties. Read patient histories, ask for clarification on unclear or seemingly illogical orders, feel free to make recommendations to the physician on the best way to accomplish the goals of the examination based on your personal experience. In short, be a thinker, not just a doer.
Six	The radiologic technologist acts as an agent through observation and communication to obtain pertinent information for the physician to aid in the	Note and document appropriate information about the patient's behavior and condition when it may be of value to the radiologist in interpreting the examination. When you receive a radiographic consultation request from the

	diagnosis and treatment of the patient and recognizes that interpretation and diagnosis are outside the scope of practice for the profession.	emergency room for an ankle series and the only patient history provided is "R/O Fx," expound on that history for the benefit of the radiologist and, ultimately, the patient. Ask the patient how the ankle was injured. Indicate on the form the location and degree of any soft tissue swelling. However, realize that our role as technologists stops short of radiographic interpretation, regardless of how tempted you may be to reveal examination findings to the patient.
Seven	The radiologic technologist uses equipment and accessories, employs techniques and procedures, performs services in accordance with an accepted standard of practice, and demonstrates expertise in minimizing radiation exposure to the patient, self, and other members of the health care team.	Ultimately, the DI technologist is the one directly responsible for protecting all others from undue or excessive exposure to radiation in the performance of his or her duties. Do not allow other hospital personnel to ignore safe radiation practices. In most instances they do not have the requisite knowledge to determine potentially unsafe exposure conditions.
Eight	The radiologic technologist practices ethical conduct appropriate to the profession and protects the patient's right to quality radiologic technology care.	Always act as the patient's advocate and with his or her best interests in mind. The patient is depending on you to provide quality DI technology care—do not let him or her down.
Nine	The radiologic technologist respects confidences entrusted in the course of professional practice, respects the patient's right to privacy, and reveals confidential information only as required by law or to protect the welfare of the individual or the community.	Respect the patient's right to privacy in matters disclosed in the course of treatment unless there is a strong indication the patient intends to harm another person, violate the law, or is being abused. In these instances, notify the proper authorities.
Ten	The radiologic technologist continually strives to improve knowledge and skills by participating in continuing education and professional activities, sharing knowledge with colleagues, and investigating new aspects of professional practice.	Continue to learn throughout your DI career. There is so much to know in our field that you'll never master everything, but each professional article you read and each class you take will make you a more competent technologist who is better able to meet the needs of patients.

004. Malpractice

In most scenarios the term *malpractice* is not normally used in connection with a DI technologist; however, there have been cases in which malpractice litigation included DI techs due to plaintiffs naming multiple defendants in an attempt to collect the largest amount of damages possible. As a result DI technologists have found themselves defending their actions in courts of law. For this reason we have developed this lesson on malpractice and the elements of a malpractice suit.

Medical malpractice

Medical malpractice is a professional negligence by action or omission of a healthcare provider where treatment provided fails to meet the accepted standard of practice within the medical community and causes patient injury or fatality involving a medical error in some form. The term *malpractice* is based on the legal concept of negligence as it applies to professionals (including health care providers). *Negligence* may be defined as the failure to perform an act or service that would normally be performed by a reasonable man in similar circumstances, or the performance of an act or service that would not be performed by a reasonable man in similar circumstances. In short the concept is based on reasonable conduct. It is a well-established principle that a medical provider has the duty to use reasonable skill and care for the safety of his or her patients. In determining medical negligence, health care professionals are measured against their peers. If a doctor, nurse, or DI technologist does

not perform to reasonable standards of competence and proficiency and a patient is injured as a result, the professional may be found negligent. In other words not knowing your job, not being careful when caring for patients, or just not thinking about what is best for the patient can result in a lawsuit if any of those things cause injury to the patient.

In any medical malpractice suit, there are four elements that must be proven by the party bringing the suit (the plaintiff)—duty, breach, proximate cause, and injury to the patient.

Duty

Every medical professional has a duty to provide *quality care*. The parameters of quality care and the scope of practice are defined by professional ethics, common law, statutes, and regulations. Whatever the accepted practice, it is generally referred to as *the standard of care*. First and foremost, the provider is required to acquire and maintain current diagnostic and technical skills. This means each medical professional must not only learn what is necessary for the basic qualifying certification but should also be aware of modern advancement and research in their field.

The element of duty in a malpractice suit means that the person (or people) being sued must have had a responsibility (duty) to care for the patient. To put it in perspective, if you are performing a radiographic examination of a patient, you have a duty to perform that examination within the accepted standards of practice for our profession. If the patient is injured as a result of your negligence (e.g., the patient falls off the X-ray table), then you may be sued because you had a duty to the patient; however, the technologist working in the next exposure room had no duty to your patient; therefore, he or she could not be sued.

The provider also has a duty to look for all relevant factors that could reasonably affect the general health of the patient. Much litigation focuses on the need for providers to understand how particular diagnostic techniques or treatment will affect the patient's health. Some of the more common concerns in the field of DI are possible allergies to contrast media and the effects of medical imaging on an unborn child.

Breach

The element of breach refers to a breach of duty to the patient. In other words the defendant must have performed his or her duty to the patient in a substandard manner. It is not enough simply to have an unsuccessful result from treatment; medicine, after all, is not an exact science. For a breach to exist, you must have in some way deviated from the accepted standards of care.

Proximate cause

Proximate cause of an injury means (1) the breach of the standard of care must actually cause the injury, and (2) the injury is one that could reasonably be anticipated when that particular breach occurs. For example in one case, the plaintiff's claim that he was left on the table under x-ray for over 3½ hours, although treatment should have lasted only 15 minutes, that he escaped only by rolling off the table onto the floor, and then hurt all over and was nervous and sick thereafter, sufficiently showed *resulting* injuries.

Injury

For malpractice to exist, there must be some element of injury resulting from the breach of duty. If you, for instance, removed a patient's C-spine collar before proper authorization from a physician, that is a breach of duty; however, if the patient received no injury as a result of your breach, there is no case for malpractice. Malpractice is a civil matter (civil liability), rather than a criminal matter. Civil matters involve violations of private rights for which monetary damages are sought as compensation. If there is no injury to the patient, there is no basis for collecting monetary damages.

Civil liability

Civil liability is a concept derived from a portion of law known as torts. Civil liability means everyone is liable for damage caused not only by acts of a person but also by negligence and carelessness. A *tort* is a civil wrongdoing that most times results in injury to a person, his or her property, or reputation in which the injured person has the right to monetary compensation. Civil liability (civil law) comes directly into play when plaintiffs look to be compensated for the act of wrongdoing against them. Many times, DI techs can get pulled into these cases in an attempt for the plaintiff to score a larger settlement as a result of a compensatory judgment.

Vicarious liability

In this concept of malpractice, vicarious liability refers to someone being held liable for negligence they did not directly commit. The most common form of vicarious liability is *respondeat superior*. The literal translation of this principle is "let the master respond." Its legal interpretation is that the supervisor (or employer) may be held responsible for the actions of his or her subordinates. Supervisors are responsible for properly training their subordinates, establishing rules and guidelines governing subordinates' actions, and ensuring compliance with these rules. Failure to do so may result in the supervisor/employer being named as a codefendant in a civil suit. In the military, this concept generally applies only to the employer—that is, the US government.

Malpractice in the military

Because the United States cannot be sued for negligence, except to the extent that Congress has enacted legislation authorizing suit, the Federal Tort Claims Act (FTCA) is the primary mechanism used by most litigants suing the federal government. The FTCA allows suits for money for injury, property loss, or death caused by the act or failure to act of any government employee performing within the scope of employment.

As military personnel one of the benefits you receive is the relative freedom from being sued personally as a result of job performance; however, the freedom from suit is not absolute. People injured or just plain frustrated by the actions of government employees can and have filed lawsuits against those employees in their individual capacities.

The first issue in any malpractice suit is often to specifically identify the parties. Exactly who is the defendant? Answering that question may not be easy. The fact your name appears in the title of a case does not mean that you have been sued individually. Government employees may be sued in either their official capacity or personal capacity. The distinction is based on whether the plaintiff seeks damages from the government or the individual employee. If the target is the government, then the real defendant is the United States.

Once determined a government employee has been sued personally, a major concern is whether the government will provide legal representation. The short answer is yes, but there are exceptions. Federal regulations provide that both current and former government employees may request representation by Justice Department attorneys. The employee request, together with an agency recommendation for approval or disapproval, is forwarded to the Justice Department. The request will be approved if the Justice Department determines that (1) the employee was acting within the scope of his or her employment at the time of the acts giving rise to the lawsuit and that (2) representation is considered to be in the best interests of the United States.

In determining "scope of employment," the question is: was the employee conducting government business at the time of the acts that instigated the lawsuit? Because of time constraints often imposed during the early stages of litigation, extensive fact-finding on the subject of scope of employment can be impractical. For that reason doubts are usually resolved in the employee's favor. The second criterion, the "best interests of the United States," is harder to define. As a practical matter, it is almost always in the government's interest to protect morale by defending federal employees who act

within the scope of employment. Additionally a clear interest can frequently be found in defending the process or integrity of the federal program involved.

Even though an individual government employee may not have to pay any money as a result of a medical malpractice suit, that does not mean there are no ramifications to the individuals involved. Whenever a medical malpractice claim is filed against the government, the medical treatment facility must identify each significantly involved provider. While the case is being reviewed, a standard–of–care determination is made for each provider. An adverse standard–of–care determination is reviewed by the Air Force Surgeon General and may result in a report to licensing or certifying agencies.

Informed consent

Because of the principle of autonomy, every adult patient must give informed consent before undergoing a medical procedure. Two exceptions to this rule include: (1) when a patient is unable to give consent due to a life-threatening emergency, and (2) in situations where the patient is not legally competent to give consent. In the latter case, consent must be provided by a parent or legal guardian. The process of informed consent involves giving the patient enough information about the benefits and risks of the procedure, as well as alternative procedures, and the risk of refusing treatment altogether. The patient must receive enough information to be able to make an intelligent decision as to the course of his or her own medical treatment. Obviously the information must be provided in a manner that the patient is able to understand, which usually requires the physician to explain the procedure in layman's terms, and in some instances may require an interpreter.

While informed consent is technically required for any medical procedure, it does not always have to involve a signed consent form. Many medical procedures (such as a routine chest X-ray) are so common and benign that the mere fact the patient presents himself or herself in the DI department for the procedure implies consent; this type of consent is called *simple consent*. In these instances all that may be required is a brief description of the examination and a signed pregnancy questionnaire for females of childbearing age.

However, any type of invasive procedure or one that involves potentially serious risks to the patient, no matter how remote, requires formal documented informed consent. The consent process requires that a physician explain the procedure to the patient in the presence of a witness. The role of the witness in the informed consent process is designed to protect patients and their rights. By law a witness must be a minimum 18 years of age and must be of normal mental competency and capacity. The witness may be a stranger, family member, or friend of the patient, but the witness ***cannot*** be a member of the procedure team tasked with performing the DI examination , including the assisting DI technologist. If a member of the procedure team serves as the witness to informed consent, it may cause two undesirable perceptions: (1) a conflict of interest, and (2) a situation where the patient feels pressured to sign the consent form. If witnesses are not appropriate, their credibility may be argued in a court of law.

Legally physicians are the only people authorized to obtain consent from patients for medical procedures. After the procedure has been explained and the physician has answered any questions the patient may have, the physician fills out a consent form including the patient's name, the name of the procedure, a brief description of the procedure, the risks and benefits of the procedure, and the name of the person performing the procedure. The patient or the patient's authorized representative and the witness must sign the form, indicating the date and time that consent was provided.

The form used should be approved by the law consultant for the facility to ensure it meets the legal requirements of the local jurisdiction. As a DI technologist, you are not responsible for obtaining consent for DI procedures; however, *you are responsible* for ensuring informed consent has been *obtained and documented* before performing the exam. At a minimum verify the presence of a signed consent form in the patient's medical chart and ensure all of the patient's questions regarding the procedure have been answered.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

003. Ethical considerations in Diagnostic Imaging

1. Morals and ethics both represent right versus wrong. Explain how they are different.

2. List the seven key components used to create most facilities' Patient Bill of Rights.

3. List four ethical principles that apply to health care delivery.

4. Explain the ethical principle of autonomy as it pertains to health care.

5. Describe the ethical principle of nonmaleficence.

6. Which ethical principle requires action to do good and prevent harm?

7. What does fidelity mean?

8. To whom does the ARRT *Code of Ethics* apply?

9. Is it permissible for you to refuse to treat an AIDS patient? Explain.

10. Who is responsible for protecting patients and other health care workers from unnecessary radiation exposure?

004. Malpractice

1. Define negligence.

2. When determining whether or not medical negligence exists, who are health care professionals measured against?

3. What are the four elements of a malpractice suit?

4. What is a tort?

5. Briefly describe the principle of *respondeat superior*.

6. For what reasons does the Federal Tort Claims Act (FTCA) allow suit for money against the government?

7. Who approves government employees' requests for legal representation?

8. What two conditions must be met for a government employee to receive legal representation by the government?

9. In what two instances is it permissible to perform a medical examination without the patient's informed consent?

10. What does the process of informed consent involve?

11. What type of consent is implied when a patient presents himself or herself in the DI department for a routine chest X-ray?

12. What types of procedures require formal documented informed consent?

13. Who may be a witness to informed consent? Who cannot?

14. Legally who are the only people authorized to obtain consent from patients for medical procedures?

15. What is your responsibility in the informed consent process?

Answers to Self-Test Questions

001

1. It is the variety of behaviors and beliefs that exist among people from different social and ethnic backgrounds or age groups.
2. Poor communication.
3. 55 percent.
4. Gestures, posture, facial expressions, touching, or eye contact.
5. By their rank and last name or Mr. /Mrs. /Ms. and their last name.

002

1. It is the official record of medical diagnosis and treatment for the patient.
2. It is meant to protect individuals' right to privacy as it relates to information kept in a system of records by the federal government.
3. It is the transfer of information from a system of records by any means of communication to organizations or individuals other than the subject or an agent acting for the subject.
4. Only with a valid power of attorney authorizing the wife access to the record.
5. PII is considered any information that can be used to distinguish a person's identity, such as (but not limited too) a person's name, SSN, date and place of birth, and mother's maiden name. In addition medical, educational, financial, and employment information are also considered PII and must be protected.
6. 1) Is the PII or private patient information necessary to the message, 2) does the recipient have a right to know the PII or specific patient information, and 3) do you have permission to release the PII or patient information.
7. Is to reduce or eliminate the use of SSN in DOD and USAF record systems.

003

1. Morals are personal rules versus ethics are rules of a profession.
2. The patient has the right to considerate and respectful care, information, privacy and confidentiality, genetic information, informed consent, refuse treatment, and dignity when dying.
3. Autonomy, nonmaleficence, beneficence, and fidelity.
4. Each individual has the right to determine the course of his or her own health care.
5. Do no evil or harm.
6. Beneficence.
7. To strictly observe duties and meet the reasonable expectations of patients regarding professional service.
8. All registered radiographers.
9. No; as health care professionals, it is our duty to care for the sick, regardless of the nature of their disease.
10. The DI technologist.

004

1. The failure to perform an act or service that would normally be performed by a reasonable man in similar circumstances, or the performance of an act or service that would not be performed by a reasonable man.
2. Their peers.
3. Duty, breach, proximate cause, and injury to the patient.
4. It is a civil wrongdoing that most times results in injury to a person, their property, or reputation in which the injured person has the right to monetary compensation.
5. Its legal interpretation is that the supervisor (or employer) may be held responsible for the actions of his or her subordinates.
6. For injury, property loss, or death caused by the act or failure to act of any government employee performing within the scope of employment.
7. The Justice Department.

8. (1) The employee was acting within the scope of his or her employment at the time of the acts giving rise to the lawsuit and that (2) representation is considered to be in the best interests of the United States.
9. (1) When a patient is unable to give consent due to a life-threatening emergency, and (2) in situations where the patient is not legally competent to give consent.
10. Informed consent involves giving the patient enough information about the benefits and risks of the procedure, as well as alternative procedures, and the risk of refusing treatment altogether.
11. Simple consent.
12. Any type of invasive procedure or one that involves potentially serious risks to the patient, no matter how remote.
13. The witness may be a stranger, a family member, or friend of the patient. The witness cannot be a member of the procedure team, including the assisting DI technologist.
14. Physicians only.
15. Making sure informed consent has been obtained and documented before performing the exam.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (001) Which technique is *not* a non-verbal communication behavior?
   a. Facial expressions.
   b. Eye contact.
   c. Language.
   d. Posture.

2. (001) Which is an appropriate method of demonstrating professionalism when interacting with a patient?
   a. Using common courtesies.
   b. Addressing the patient by his or her first name.
   c. Asking the patient for their phone number.
   d. Performing a PA chest radiography on a male with his shirt off.

3. (002) A violation of a patient's right to privacy is accessing
   a. lab results from a colleague's recent primary care visit.
   b. third-party collection information during patient arrival.
   c. lab results for injection of contrast media for an intravenous urogram.
   d. a radiology report from an outside provider for radiologist comparison.

4. (002) In which format are you allowed to send encrypted personally identifiable information (PII) electronically?
   a. Instagram if the patient's name has been removed.
   b. Facebook with for official use only (FOUO) disclaimer at the beginning of the message.
   c. Through e-mail with a FOUO in the subject line and a privacy act statement at the beginning of the message.
   d. Through e-mail with a FOUO disclaimer in the subject line and a privacy act statement at the end of the message.

5. (003) What ethical principle is based on the individual's right to determine the course of his or her own health care?
   a. Fidelity.
   b. Autonomy.
   c. Beneficence.
   d. Nonmaleficence.

6. (003) What ethical principle requires *action* on the part of health care workers to prevent harm to patients?
   a. Fidelity.
   b. Autonomy.
   c. Beneficence.
   d. Nonmaleficence.

7. (003) How many principles are there in the American Registry of Radiologic Technologists (ARRT) standards of Ethics?
   a. 2.
   b. 10.
   c. 12.
   d. 20.

8. (004) What are the four elements of a medical malpractice suit that must be proven by the party bringing the suit?
   a. Duty, breach, proximate cause, and injury.
   b. Duty, fidelity, breach, and injury.
   c. Intent, breach, proximate cause, and injury.
   d. Duty, intent, fidelity, and breach.

9. (004) The legal concept that states a supervisor can be held responsible for the actions of his or her subordinates is called
   a. quid pro quo.
   b. res ipsa loquitur.
   c. respondeat superior.
   d. contributory negligence.

10. (004) In which instance may medical treatment be given without informed consent?
    a. A 40-year-old patient with breast cancer who requires chemotherapy.
    b. A 3-year-old patient who requires sutures to treat a facial laceration.
    c. An 80-year-old patient who has fallen and has a broken hip.
    d. A 20-year-old patient who was involved in a motor vehicle accident and is unconscious.

11. (004) Which task related to the informed consent process is the responsibility of the radiologic technologist who will be assisting in the procedure?
    a. Prepare the consent form for the patient's signature.
    b. Sign the consent form as a witness before beginning the procedure.
    c. Inform the patient of the risks and benefits of the medical procedure.
    d. Ensure informed consent has been obtained before beginning the exam.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Infection Control

INFECTIONS have always been one of our greatest health risks. In the fourteenth century, the Bubonic Plague (a bacterial infection) destroyed almost a quarter of the world's population. Over the past 30 years, the world's population has dealt with the outbreak of the acquired immunodeficiency disease syndrome (AIDS), the Hantavirus (a respiratory syndrome), E. coli, the bird strain of influenza called H5N1, and most recently, the Ebola virus. Unfortunately this risk of infection is not limited to sources outside the hospital. Current statistics show that around 2 million hospitalized patients acquire some sort of infection while they are admitted to a medical treatment facility (MTF), and there are estimates that state approximately 90,000 patients die annually from hospital-acquired infections.

In the past many of the infections that occurred in medical facilities could be attributed to ignorance. Aseptic techniques were limited or nonexistent. Patients with different illnesses were placed together, and medical personnel did not clean themselves or their patients. As you can imagine, infections spread very quickly in such environments. Around the middle of the nineteenth century, Hungarian physician Ignaz Semmelweis introduced infection control when he required other physicians to wash their hands after performing procedures, such as autopsies, and before examining other patients. His precepts were reinforced by other medical leaders like Florence Nightingale, who placed a high level of importance on personal cleanliness and a clean environment. Infection control techniques continued to develop with the discovery of microorganisms and antibiotics and with the use of isolation techniques and barriers. These principles and techniques have evolved into the modern infection control measures we practice daily. In this unit we discuss the various types of infection control used in Air Force medical facilities. We begin by looking at the infectious process itself. We will explain types of infectious agents, characteristics of the infection chain, prevention measures for nosocomial infections, and infection control programs.

2–1. Infectious Process

Although there are literally millions of microorganisms capable of causing disease, relatively few people actually develop illnesses. The reason for this, and the key to controlling infection, lies in the nature of the infectious process. As illustrated in figure 2–1, the infectious process or "chain" is made up of six interlocking links. The links include an infectious agent, a reservoir, a portal of exit, a mode of transmission, a portal of entry, and a susceptible host. These links must form a continuous cycle for

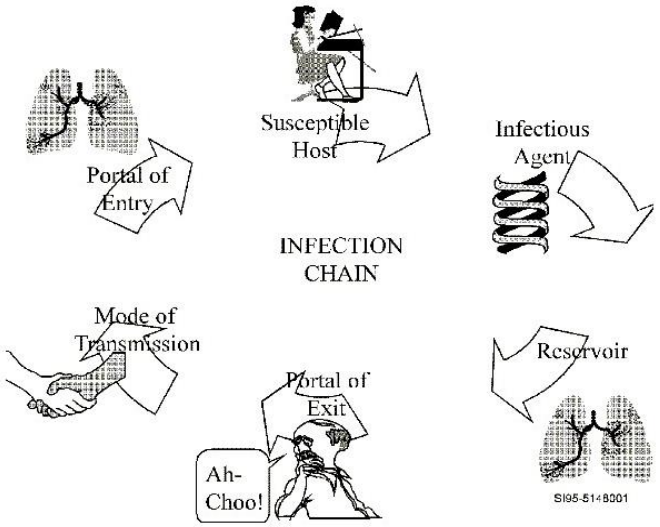

Figure 2–1. Infection chain.

infection to develop and/or spread. In this section we discuss the characteristics of each link and show how they interact.

005. Infectious agents

Before we discuss the infection chain, we want to emphasize that there really are no hard and fast definitions or rules for the relationship between microorganisms and their human hosts. The science of both microbiology and medicine is changing almost daily. In this text we use the definitions and rules that are most commonly accepted at this time.

Chain of infection

The chain of infection begins when an infectious agent finds a location (reservoir) where it can grow and multiply. The agent multiplies and some of the resulting offspring leave the reservoir through the portal of exit. These offspring are carried by whatever mode of transmission is characteristic for that agent to a susceptible host. The *host* is the organism (frequently a human) that harbors or allows the agent to grow and reproduce. Once in the host, the agent invades the tissues until it finds a location (reservoir) where it can grow and multiply. The agent causes an infectious state within the host by destroying cellular components or releasing toxic substances. From this summary, you should see the overall relationship of the infection chain components. We will now discuss the characteristics of these components in more detail.

Infectious agents

The infectious agent actually is more like the central figure in the infectious process rather than a part of the chain of infection. Each link of the chain is related to something that the infectious agent is doing to produce the infectious state.

Infectious agents are minute organisms that invade and inhabit tissues in various parts of the body. These organisms cause disease by producing toxic substances *or* destroying parts of the cell they have invaded. These agents are commonly referred to as *microorganisms* because most of them are so small they cannot be seen with the naked eye. Although the great majority of microorganisms are infectious, some are not. For example adult helminths (worms) are large enough to be seen without a microscope; yet, some forms can invade body tissues and cause disease. The term *pathogen* is used to accurately refer to organisms that *cause* infection and disease. Nonpathogens are organisms that normally do not cause infections.

Characteristics of microorganisms

Microorganisms exist in almost every aspect of our environment, including both in and on our bodies; however, most forms cannot survive in a human or animal environment and normally do not pose a threat to us. There are several terms used to describe some of the characteristics of microorganisms and the interesting relationships they have developed with their human hosts. We discuss some of these in the following paragraphs.

Normal flora

Shortly after our birth, a number of different microorganisms inhabit various parts of our bodies. These microorganisms vary from person to person and generally are drawn from whatever source a person is exposed. Microorganisms found in a specific body area are referred to as *normal flora* for that area. Normal flora exists in a state of equilibrium with the host; the microorganisms of normal flora are potentially pathogenic, but as long as nothing disturbs the balance, they are not harmful. In some cases, normal flora can be beneficial. One example is the *E. coli* bacteria that are normal flora for the intestinal tract. *E. coli* are involved in the production of vitamin K, which plays an important role in the clotting process.

Normal flora becomes pathogenic and causes disease when the balance within the body is disrupted. Disruption may be caused by disease, antibiotics, or the exposure of normal flora to other parts of the human body than for which it is designated. Another cause of disease is when microorganisms of

normal flora from one person are transmitted to another person. In fact many of the infections in hospitalized patients are caused by the activity of normal flora.

Commensalism

When pathogens invade a host and attempt to cause disease, the host usually responds by trying to either destroy or eliminate the microorganism. Sometimes after repeated exposures and constant unsuccessful attempts to eliminate the pathogen totally, the host develops a tolerance for the invading pathogen. Such a relationship is called *commensalism*. As long as nothing disturbs the balance, the pathogenic organism is able to live inside the host without producing an infectious reaction. As with normal flora, however, if the balance is disturbed, commensal organisms can cause infection and disease.

Carrier state

As a general rule, most microorganisms are nonpathogenic, a few are weakly pathogenic, and some are strongly pathogenic. Strongly pathogenic microorganisms cause disease in almost every person they invade. A few individuals are able to withstand the effects of the pathogen. The pathogen inhabits their bodies but does not produce any symptoms of infection. These individuals are called *carriers* because they are asymptomatic but are still able to pass the pathogen onto other, more susceptible individuals. One famous example of a carrier was Mary Mallon, also known as Typhoid Mary. Typhoid Mary was a cook in New York City in the early 1900s. She was diagnosed as a carrier of typhoid fever in 1907, but she continued to practice her profession until 1915. It is estimated that she was responsible for at least 10 outbreaks of typhoid fever, with at least three associated deaths.

Infectious state

Infection is the pathogenic relationship with which we are most concerned. An infection occurs in the human body when one of the infectious agents invades the body through one of the portals of entry, finds an area that meets its needs, and begins to grow and reproduce itself. The infectious agent acts as a parasite by using parts of the surrounding body tissues as nutrients. Some forms also release toxic substances into the tissues. The host reacts to this invasion by activating specific and nonspecific defense mechanisms. The activity of these mechanisms produces certain symptoms (fever, inflammation, etc.) in the host. If the infection progresses into an actual disease, the host develops symptoms that are characteristic for that particular disease.

A pathogen will not develop into an infection unless it can find an environment that is favorable for its growth and can withstand the host defense mechanisms. In addition to these requirements, there must be an adequate dose of the microorganisms, and they must possess some degree of virulence. These factors are interdependent and highly individualized with each type of microorganism.

The dose refers to the number of microorganisms that have invaded the host. An infection usually will not occur if only a single microorganism or a few microorganisms invade a host. Most microorganisms are not virulent enough to overcome host defenses in such small doses. On the other hand, a large dose will overcome even a strong host defense. Two characteristics that determine the size of the pathogen dose required to cause an infection are (1) the type of organism involved, *and* (2) the condition of the host.

Virulence

Virulence is a *measure* of the pathogenicity or ability of the organism to invade host tissues, withstand defenses, and cause an infection. The ability to move through tissue is sometimes referred to as "invasiveness." Virulence of a microorganism is based on two characteristics: aggressiveness *and* toxicity. Aggressiveness is the rate of growth and multiplication of an organism. An organism that is highly aggressive grows or spreads very quickly. This growth is, in turn, affected by the condition of the host and the location that the organism is attempting to invade. If the host defenses are compromised, or if the organism finds an area that is highly favorable, it will become very

aggressive. For example when normal skin flora gets into a cut, they usually become aggressive and cause an infection.

Toxicity is the second aspect of virulence. When some pathogens invade body tissues, they release poisonous substances called *toxins*. These toxins reduce host resistance, destroy tissues, and cause disease. A pathogen does not need to be aggressive to be virulent. If it produces toxins, it can still cause serious disease. Each toxin has a specific chemical structure, and it affects a specific part or parts of the body. Thus, it is possible to determine what microorganism is involved, according to the part of the body that is affected and the symptoms produced.

Types of infectious agents

You should be aware of the characteristics of the common types of infectious agents. These include bacteria, fungi, protozoa, viruses, and helminths. The following information will increase your awareness.

Bacteria

Bacteria are primitive, one-celled, plant-like organisms that reproduce rapidly. Some forms are pathogenic, but others are essential for life. Under favorable conditions, reproduction is extremely rapid. On the average, bacterial cells divide every 30–120 minutes. At this rate, one cell can develop into several million within a day or so. Fortunately there are factors that retard bacterial growth.

There are over 1,700 different types of pathogenic bacteria. They are classified according to their physical characteristics. Physical characteristics of bacteria include size, shape, and attachments. There are three basic bacterial shapes (figs. 2–2, 2–3, and 2–4):

Type	Shape	Illustration
Cocci	Spherical	 COCCUS **Figure 2–2. Spherical shape.**
Bacilli and coccobacilli	Rod	 BACILLUS (rods) **Figure 2–3. Rod shape.**
Vibrios, spirilla, and spirochetes	Spiral	 SPIROCHAETES **Figure 2–4. Spiral shape.**

Bacterial attachments include protective capsules and hair-like outgrowths called *flagella*, which help propel the cell. When a laboratory technician attempts to identify bacteria, he or she looks at the shape and sees if the bacteria will stain. If the bacteria will hold a Gram stain, it is referred to as *Gram positive*; if the staining fails, it is called *Gram negative*.

Bacterial cells have the ability to adapt to survive in some extremely unfavorable conditions. Some cells react by becoming dormant until they are exposed to a more favorable environment. Other cells adapt by forming capsules and spores. A capsule is a slimy layer that is formed on the cell's outer layer. A spore is a thick-walled structure formed within the cell that contains the essential cellular structures in a dehydrated, condensed form. This spore can withstand extreme environmental conditions, and it can last for an indefinite period of time. Bacterial cells that form spores become dormant until conditions are favorable and they can resume their cellular activities.

The physiological requirements of bacteria include oxygen and nutrition. Most bacteria are called *aerobic* because they require oxygen to survive. Those that survive without oxygen are called *anaerobic*. The nutritional source is an important factor both in classifying the bacteria and in determining its relationship with us. Bacteria that obtain their nutrition *from* living sources are called *parasites*. These include all forms that inhabit our bodies.

Fungi

Two structural categories of fungi are yeasts *and* molds. They range in size from single-celled microscopic organisms to structures like mushrooms and puffballs, which can be seen easily. Fungi do not produce oxygen nor do they require sunlight for energy (they do not possess chlorophyll). Their main source of nutrition is dead and decaying matter. They have a rigid cell wall structure, and most forms grow as branching filaments (like the branches on a tree). Fungi are best adapted to a warm, dark, moist environment, but like bacteria, they can survive in some fairly extreme environments. They are nonmotile, except when in the spore stage. Like bacteria, fungi are capable of both pathogenic and nonpathogenic activities; however, most are nonpathogenic. Some types of fungi are edible (mushrooms); others are involved in the fermentation of breads and alcoholic beverages and the production of antibiotics, such as penicillin. Fungi cause a number of superficial and systemic infections including athlete's foot, ringworm, histoplasmosis (a respiratory infection), oral thrush, and vaginal candidiasis.

Protozoa

Protozoa are single-celled structures that resemble animal cells because they are surrounded by cell membranes rather than cell walls. Because their cell walls are flexible, they assume a variety of shapes. Protozoa usually are found in a fluid environment that can be anything from a drop of water to an ocean. The protozoa that we are concerned with are those forms that live as parasites in the blood or tissue fluids of animals or humans and are pathogenic for humans.

Protozoa cannot form a spore as bacteria and fungi do. Instead they react to unfavorable environmental conditions by assuming a rounded shape and secreting a protective cyst-like covering. This cyst-like covering allows the protozoa to withstand environmental changes and survive during the transfer from one host to another. When the protozoa are placed in a fluid environment, they resume their normal activities and shape.

Viruses

Viruses are the *smallest* known microorganism. They lack both a cell wall and a distinct nuclear structure. Each virus consists of a strand of nucleic acid (deoxyribonucleic acid [DNA] or ribonucleic acid [RNA]) that is surrounded by a layer of protein called a *capsid*. In some cases, they are also surrounded by a membrane. Viruses are intracellular parasites. They survive by entering a host cell and altering its reproductive structures to produce additional viruses and proteins. These new viral structures are then released to invade other cells. The original cell either is broken down through a process called *lysis* or continues to grow and produce viral structures.

Viral cells are specific for certain parts of the body. For example the measles virus affects skin cells, rabies affects the brain and spinal cord, and yellow fever affects the liver. Viruses are responsible for a multitude of infectious diseases ranging from the common cold to smallpox, rabies, etc. There is even some evidence that viruses are responsible for some forms of cancer.

Helminths

The last type of infectious agent we discuss is helminths or worms. Helminths are not microorganisms and normally do not cause infectious diseases. We include them in our discussion of infectious agents because they are parasites that infest human hosts, and most importantly, because they are "infectious" and can be transmitted from one person to another.

There are a great many different types of helminths infesting our bodies. We do not have the time or the space to discuss all of them in this text. Characteristically those forms that affect humans have life cycles that include adult, egg, and larval (immature) stages. These life cycles may occur totally within the human host, or they may involve an intermediate host. Typically the helminth enters a human host in one of the larval stages. The larva migrates to the intestine or other part (liver, lungs, blood vessels, subcutaneous tissue, or brain) of the host's body and develops into the adult form. The adult helminth undergoes reproduction and produces eggs that are then expelled through one of the body's waste mechanisms. The eggs are ingested by an intermediate host, where they penetrate into the tissues and mature to form the larval stage again. Another human is infected when he or she eats improperly prepared, intermediate host tissues. Figure 2–5 shows the life cycle of the beef tapeworm, Taenia saginata.

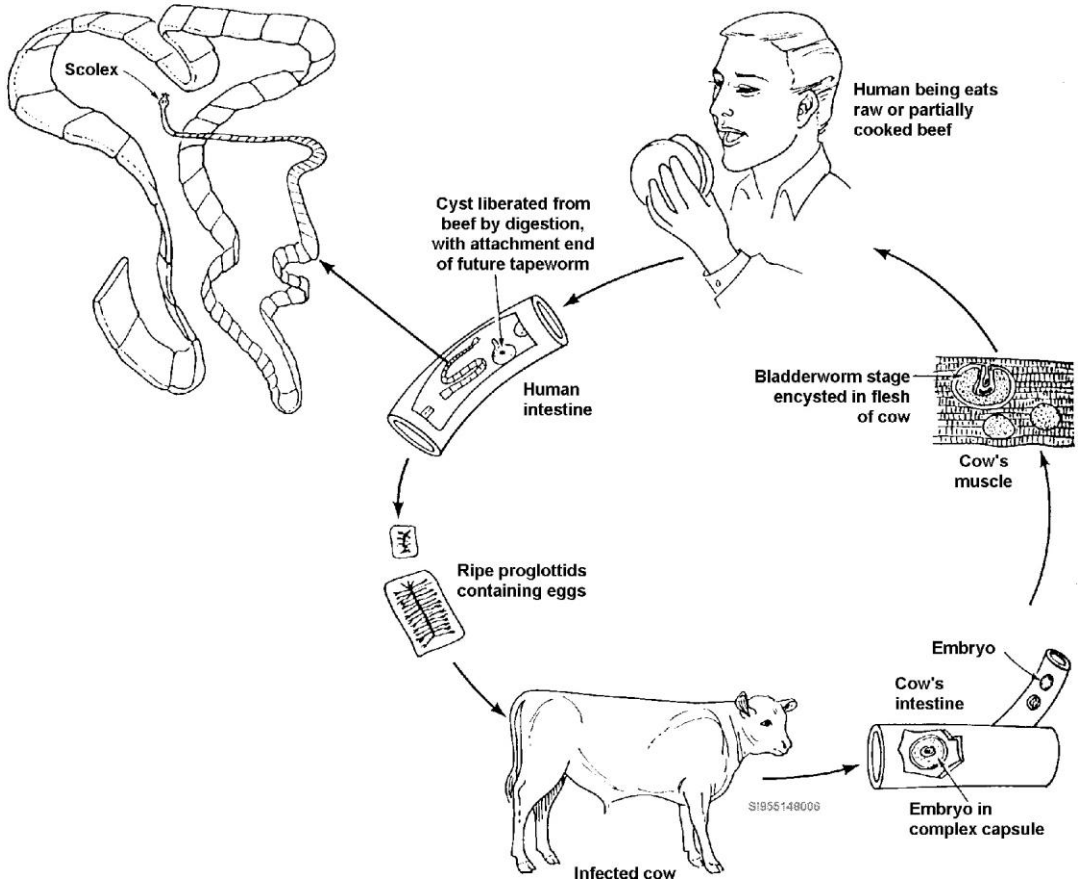

Figure 2–5. Typical helminth life cycle.

006. Characteristics of the infection chain

As we indicated at the beginning of this lesson, the first link in the infection chain is a location where the infectious agent can grow and multiply. This location is known as the *reservoir*.

Reservoir

A reservoir is a favorable environment *and* source of nutrition for an infectious agent. Each infectious agent has specific requirements for oxygen, temperature, moisture, light, pH, a source of nutrition, etc. An environment favorable for one infectious agent might kill another. For example certain types of bacteria require oxygen and a warm, dark, moist environment, but other types of bacteria cannot survive in such an environment. When an infectious agent is placed in an unfavorable environment, it

either dies or changes to a dormant stage (cyst, spore, etc.). When that happens the chain of infection is broken.

We will not list the requirements for all the different infectious agents, but it is important you understand there are a wide variety of potential reservoirs in our environment. In many cases these reservoirs are located within a human or animal host. Humans act as reservoirs when they have an infectious disease. When their hands or other body parts have become contaminated with an infectious agent they are acting as carriers. Animals may have the disease or they simply may be acting as intermediate hosts. Pathogenic organisms require a warm, moist environment similar to that found in the human body, and the most likely reservoirs will have similar conditions; however, since we can't see most of these organisms, the only safe practice is to always assume the potential reservoirs are contaminated.

Portal of exit

The most dangerous aspect of infectious agents is *not* the disease that they can cause but rather the fact that the disease can be communicated from one person to another. Infectious agents act by invading, multiplying, and causing disease in one reservoir, then moving onto another. Most of this activity takes place inside a host. The infectious agent must first find a way to leave that reservoir (host) before it can be transmitted to another host. This is called the *portal of exit*, and it is the next link in our infection chain.

If you recall our discussion of helminths and protozoa, the portal of exit in humans is usually related to elimination of some waste product (urine, feces, oral-nasal secretions, and genital secretions). Exit portals are normally the mouth, nose, anus, urethral meatus, and occasionally, the eyes. Of particular interest to us, infectious agents also exit the body in blood and through the drainage of wounds.

Modes of transmission

The third link in our infection chain is the mode of transmission or the mechanism by which an infectious agent travels from one host to another. These mechanisms are directly related to the life cycles, physiological requirements, and survivable capabilities of each infectious agent. Obviously these factors will vary considerably from one infectious agent to another. For example an anaerobic type of bacteria would not be able to survive if the mode of transmission involved exposure to oxygen; however, if those same bacteria could form a spore, it could survive virtually any type of transmission.

There are five major modes of transmission: (1) contact transmission, (2) droplet transmission, (3) common vehicle transmission, (4) airborne transmission, and (5) vector-borne transmission.

Mode of Transmission	Explanation
Contact	Includes direct contact or actually touching the source of the infectious agent. For example, you make direct contact if you touch contaminated drainage when you are doing a procedure. Direct contact also includes activities such as kissing and sexual intercourse. Contact transmission also includes indirect contact. Indirect contact involves touching an object that has been contaminated by contact with the reservoir. Contaminated dressings, soiled sheets, instruments, etc., are all objects frequently contaminated in the hospital by indirect contact. If you handle these items, you become contaminated by indirect contact.
Droplet	In the past was considered a form of contact transmission, usually involving respiratory secretions that are expelled when a sick person coughs, sneezes, or talks, or by procedures such as suctioning or bronchoscopy. Such droplets usually do not travel more than three feet from their original source. You become contaminated if you are within that range and come into contact with those droplets.
Vehicle	Defines how microorganisms are transmitted by food, beverages, drugs or medications, blood, or intravenous (IV) lines. Remember our example of Typhoid Mary? The food she prepared became contaminated and acted as a common

	source of transmission for the people who ate it. The same thing happens when there is an outbreak of food poisoning in a restaurant or someone's home. A source of contamination is shared by a number of people. Contaminated blood or IVs are a little different in that they are not shared by several people; however, one source of contamination can infect an entire blood supply and thereby affect many people.
Airborne	Occurs when infectious agents or spores of infectious agents become suspended in the air in dust particles, aerosols, sprays, or even droplets. These agents can remain suspended for a long period of time and can be carried for long distances on air currents.
Vectors	Are insects *and* rodents that transmit the infectious agent by biting, stinging, or depositing the agent either directly on the new host or on some object that will come in contact with the new host. In some cases, the vector is acting as an intermediate host, and at other times the vector is simply contaminated.

Portal of entry

Portal of entry is the way that infectious agents enter the body. This is also a necessary link in the infection chain. As we mentioned earlier, there are all sorts of microorganisms on our skin and the objects with which we come into contact. These microorganisms seldom cause an infection because they usually cannot get past the skin.

Portals of entry include the mouth and nose (most common), eyes, genital openings, anus, and breaks in the skin from wounds or invasive therapy. These portals are usually specific for each microorganism. Organisms that are normal flora for one part of the body, for example, will not cause an infection unless they pass through a different entry portal to another part of the body. Generally speaking a portal of entry is a link in the infection chain only if it allows an infectious agent to penetrate an area of the body where there is a favorable environment for that particular organism.

Susceptible host

The last link in the infection chain is a susceptible host. This is a person whose body has been penetrated by the infectious agent and in whom a disease condition develops. This person must be susceptible because a normal, healthy person has a number of defense systems that protect him or her from most infections. A person becomes a host when these defenses break down in some manner and allow disease-producing microorganisms to enter and produce a reaction. We use the term *susceptible* to indicate that conditions exist that will allow infectious microorganisms (agents) to penetrate the host's defenses. Let's review the different defense mechanisms.

Defense mechanisms

If you recall from your anatomy and physiology, your body's first line of defense against pathogen invasion is your *skin and mucus membranes.* As long as the skin remains unbroken, few microorganisms are able to enter the body; those that do, enter through the mouth and nose. In the nose the mucous membranes and cilia participate by trapping foreign particles as they enter. These particles can then either be swallowed or expelled by sneezing or coughing. Most of the particles swallowed are destroyed by enzymes and chemicals in the stomach.

Mechanism	Explanation
Interferon	Is a protein substance made by leukocytes. The interferon is produced by the cell in response to an invading virus and seems to interfere with viral reproduction. The interferon also enters neighboring cells and provides them with the same immunity. Research goes on regarding the use of interferon as a treatment for cancer and AIDS.
Inflammatory response	Is another defense mechanism used by the body in response to invading organisms. The inflammatory response can be noted by heat, redness, swelling, and pain at the entry site. This response is the body's attempt to localize a possible infection. It also provides an area for phagocytosis. Phagocytosis is the process of ingestion and digestion of foreign substances.

Mechanism	Explanation
	The phagocytes simply eat up anything that may be harmful to your body.
Immune response	Is a very complicated mechanism that is initiated by the B cells (a type of lymphocyte). When an antigen enters the body, the B cells begin the process of antibody production. Antibodies also are referred to as "immunoglobulins." Once the antibodies are activated, they are capable of destroying the invading antigen. The human body has two different types of immunity: natural and acquired.
Natural immunity	Is present at birth. These particular defenses are acquired through heredity and race.
Acquired immunity	Is obtained by having the disease (naturally acquired active immunity), receiving immunizations of live or artificial antigens (artificially acquired active immunity), or receiving actual antibodies (passive immunity). Passive immunity is short-lived—several weeks to a few months—and will provide only temporary protection for the individual.

Characteristics of the host

Certain conditions or characteristics reduce resistance and make a host more susceptible to infection. These include age, sex, race, environment, state of health, disease processes and injuries, medications and treatments, and exposure and susceptibility to microorganisms. Of these the characteristic that most affects the host as a link in the infection chain is the level of susceptibility. Susceptibility is the amount of resistance the host has to the pathogen. Since our natural and acquired defensive mechanisms provide the resistance, susceptibility also is a measure of the effectiveness of these mechanisms. The host who has a high level of susceptibility will not be able to resist the pathogen, and infection will result.

Obviously the state of health of both the potential host and the specific agent involved has a bearing on whether an infection occurs. A person weakened by disease or injury is more susceptible than he or she normally might be. As we discussed earlier, some pathogens are more virulent than others. Many pathogens are so contagious that they overcome any resistance a host can provide. The other factors we mentioned also affect susceptibility, although not always in ways that are clearly understood. For example certain races are genetically inclined to be susceptible to certain diseases. In turn these diseases make them susceptible to infectious processes.

A susceptible host will become a reservoir if an infectious agent is able to overcome the host's defenses and find a favorable location for growth and multiplication. When this happens the host either develops the infectious process or becomes an asymptomatic carrier for the infectious agent. Although we have said that the host is the last link in the infection chain, you should be aware that this process is cyclic. The contaminated host becomes a reservoir, and the cycle begins again.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

005. Infectious agents

1. List the components of the chain of infection.

2. What are two ways that infectious agents cause disease?

3. How are microorganisms found in a specific body area referenced?

4. What happens when the balance between normal flora and the body is disrupted?

5. What is the name of the relationship that sometimes develops when a host is exposed repeatedly to a pathogen but is *never* successful in eliminating it totally?

6. How do carriers differ from individuals who actually develop an infectious disease?

7. Explain what happens when an infection occurs in the human body.

8. What two characteristics determine the size of pathogen dose required to cause an infection?

9. What are the two characteristics that affect the virulence of a microorganism?

10. What are the three basic bacterial shapes?

11. What are the two structural categories of fungi?

12. How do protozoa react to an unfavorable environment?

13. What is the smallest known organism?

14. Describe the structure of a viral cell.

15. What are the life-cycles for the helminths that affect humans?

16. Normally what stage of life is a helminth in when it enters a human?

006. Characteristics of the infection chain

1. For an infectious agent, what must a reservoir provide?

2. What is the *only* safe practice regarding reservoirs?

3. What is the *most* dangerous aspect of an infectious agent?

4. What are the normal exit portals for infectious agents?

5. Describe indirect contact.

6. How is an infectious agent transferred by vehicle transmission?

7. Describe airborne transmission.

8. Why do *most* of the microorganisms on our skin *not* cause infections?

9. What does the term *susceptible* mean when it is used to describe a host?

10. What type of immunity is present at birth?

11. What are the three ways a person acquires immunity?

12. What conditions reduce resistance and make a host *more* susceptible to infection?

13. When will a susceptible host become a reservoir for an infectious agent?

2–2. Infection Control

Infection control is an ongoing program that affects everyone in a hospital, both patients and staff. There is a chance that a small percentage of all patients will develop nosocomial infections. Nosocomial infections are defined as infections that patients acquire as a result of treatment in a medical facility. Every year, a significant number of hospital personnel develop nosocomial infections. This problem is considered so serious that the Centers for Disease Control and Prevention (CDC) recommend all medical facilities establish an ongoing infection control program to deal with the problem of nosocomial infections. The Joint Commission (formerly the Joint Commission on Accreditation of Healthcare Organizations [JCAHO]) endorsed and expanded ongoing infection control programs, which also has made infection control programs one of the basic criteria for hospital accreditation.

In this section we discuss nosocomial infections and how various infection control procedures break the chain of infection and halt the infectious process. The techniques we discuss here include handwashing, employment of standard precautions, and the use of transmission-based precautions.

007. Preventive measures for nosocomial infections

As previously mentioned there is a possibility that patients may develop nosocomial infections during treatment. In terms of time, supplies, and equipment, the cost of such infections can be calculated in billions of dollars. In terms of patient suffering, the figure is incalculable. As part of your responsibility to provide the best possible care for your patients, you must do everything you can to prevent nosocomial infections. To do this you must learn what causes these infections, what the contributing factors are, and what nursing measures will prevent them.

Causative factors

Causative factors can be divided into two categories: (1) actual infectious agents (microorganisms) that cause disease, and (2) patient condition or method of care that contributes to the infections.

Actual infectious agents

Gram-negative aerobic bacilli cause most nosocomial infections. These include Klebsiella, Enterobacter, Pseudomonas, Serratia, Proteus, and Escherichia coli. Other infectious agents include Gram-positive bacteria (Staphylococcus aureus), viruses (Rotavirus), fungi (Candida) or protozoa (pneumocystis). These infectious agents normally are not pathogenic; they are commensal or part of the patient's normal flora that become opportunistic and invasive when the patient's condition weakens.

Over the years though, the overuse of broad-spectrum antibiotics has created a group of multidrug-resistant Gram-positive infections. A few of these nosocomial infections are methicillin-resistant staphylococcus aureus (MRSA), vancomycin-resistant enterococci (VRE), and clostridium difficile colitis (C. diff). MRSA and VRE can cause surgical wound, urinary tract, and bloodstream infections and are very difficult to treat, while C. diff is a gastrointestinal infection-causing diarrhea. Patients receiving intense antibiotic treatment are most often susceptible to C. diff infections due to the antibiotics ability to upset the normal balance of intestinal flora within the human body.

Contributing factors

The factors that contribute to nosocomial infections are patient condition, type of treatment/therapy, exposure, and employee carelessness.

Patient conditions

Any illness will cause some deterioration of the body's defense mechanisms and make the patient more susceptible to infections. Illnesses or injuries that directly affect the immune system are especially hazardous. For example patients with AIDS are highly susceptible. Patients who have burns or other injuries that damage the skin also have increased susceptibility. Sometimes age is a

factor in susceptibility. Elderly patients are highly susceptible because their systems are deteriorating. At the same time, infants and young children are more susceptible because their systems are relatively immature.

Treatment and therapy

Many of the new diagnostic techniques involve some sort of invasive procedure. For example a doctor can examine a heart by cardiac catheterization; however, this procedure potentially allows pathogens to invade new areas of the body. We also use a great many invasive procedures for treatment and therapy. Urinary catheters, IV lines, nasogastric tubes, etc., allow us to do more for the patient in terms of treatment and diagnosis; however, they also open the door for a great many pathogenic microorganisms to enter the body. In fact urinary catheters and IV lines are two of the leading causes of nosocomial infections! Contaminated equipment or IV fluids and blood are also sources of infection. Certain types of therapy actually *suppress* the immune system; for example patients receiving steroid therapy and cancer patients receiving chemo/radiation therapy. Any of these forms of therapy depress the immune system.

Lastly with the overuse of antibiotics/antimicrobials throughout recent decades, patients are more susceptible to opportunistic infections like MRSA, VRE, and C. diff because the normal flora has built-up a resistance to the medicines designed to eradicate the microorganisms.

Exposures

A hospital is one of the least healthful places in the world. It is where people go when they are sick. Their lower resistance, in combination with the endemic microorganisms in the MTF environment, increases opportunities for cross-contamination. Patients in intensive care or special care units have an increased chance of exposure because they are sicker than other patients are and they are placed closer together.

Employee carelessness

Carelessness may be one of the major contributing factors for nosocomial infections. Staff members who accidentally contaminate equipment/supplies, and then use the same equipment/supplies on a patient, risk causing nosocomial infections. How many times have you seen a fellow staff member provide a form of patient care and then not wash his or her hands?

Preventive measures

The *most* basic and important preventive measure you can perform to fight the spread of infection is washing your hands. We will discuss handwashing in another lesson, but generally speaking you should wash your hands before and after you provide any patient care. The type of handwashing (routine versus antiseptic versus surgical scrub) will be in accordance with the procedure you perform. Other preventive measures include isolation techniques, strict aseptic technique for invasive therapy, close surveillance to identify potential infections and prevent contamination, and methods to monitor staff aseptic practices.

Breaking the infection chain

The last topic in this lesson actually relates to the whole topic of infection control. The result of sound infection control practices ensures that we stop the infectious process.

Look at figure 2–6 and note each link in the infection chain is separated from the next link by certain activities. Beginning again with the infectious agent, you can see we use handwashing, antibiotic therapy, and cleaning and disinfecting techniques to stop agents from reaching their reservoir. If they can’t reach their reservoir, they won’t be able to grow and multiply.

In the next link, we deal with microorganisms that have established themselves in a reservoir. If the reservoir is a human host, we use isolation techniques to prevent its spread. Depending again on

where the microorganisms are, we use antibiotics, chemicals, or other means to destroy the organism or to prevent it from leaving the reservoir.

If the microorganism does leave, handwashing and proper treatment of waste products will help prevent its transmission. At the other end of the transmission, we can again use handwashing, as well as gloves and other sterile techniques, to prevent it from reaching a portal of entry in a new host.

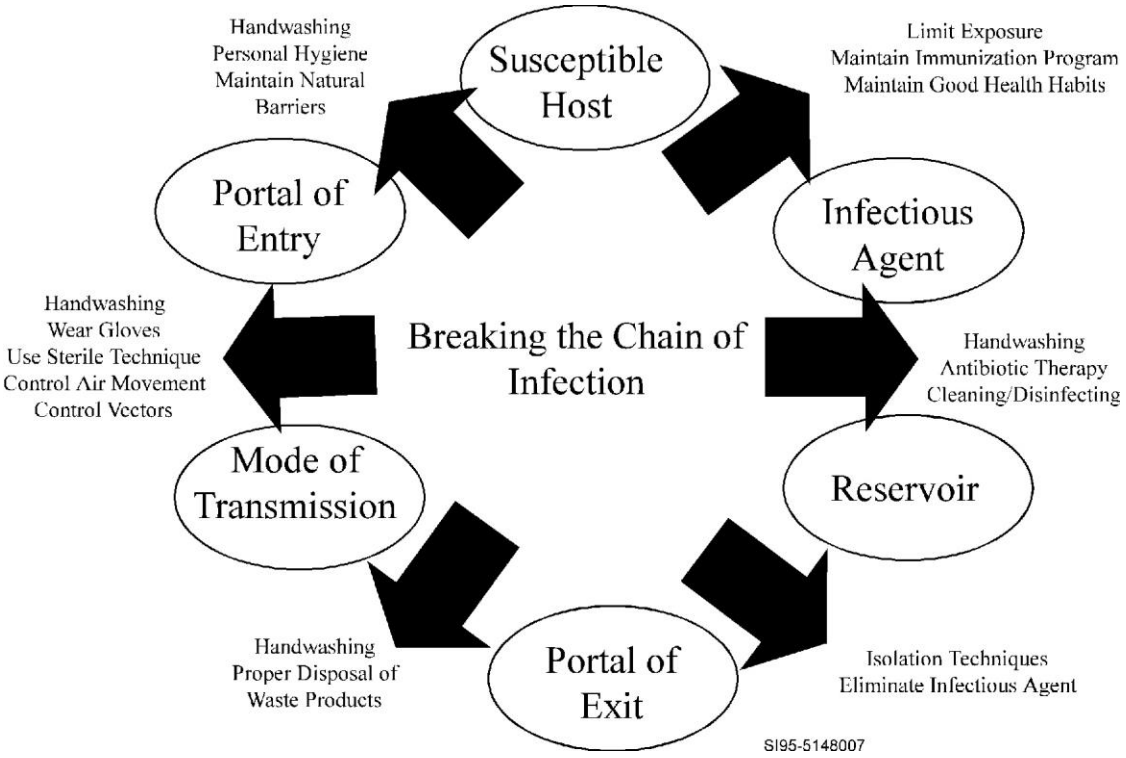

Figure 2–6. Breaking the infection chain.

The best personal defenses against infection are good health, proper hygiene, and natural barriers. Even if a microorganism does manage to enter your body, you have an excellent chance of resisting it if your natural defenses are working. You'll also be able to prevent microorganisms from establishing a reservoir in your body if you limit your exposure to infectious agents. Logically if you hang around a room full of sick people, you'll probably become sick yourself. Of course in your occupation, you may not have a choice, but you can still take precautions. Keep your immunizations current. The Air Force does all the memory work for you; all you have to do is go to the immunization clinic to get your shot when you are notified. Again maintaining good health habits is the best way to decrease your susceptibility to infection.

Asepsis

Sepsis is a term, which means "infection." *Asepsis* means the "absence of infection." As health care workers, we strive to reduce or eliminate all possible sources that could spread infections. Reducing, destroying, or eliminating pathogens are some of the ways in which we strive for asepsis. To achieve our goals, there are a few things we need to keep in mind.

First, asepsis can be achieved on inanimate objects but not on people. Even though most microorganisms require a specific environment and can be destroyed by being exposed to environmental extremes, many microorganisms are capable of developing into forms (spores, cysts, etc.) that can survive environmental changes. The human body, on the other hand, is relatively fragile

and it is *not* possible to kill the microorganisms on our bodies without damaging ourselves in the process; however, it *is* possible to destroy all the microorganisms on an inanimate object.

Second, limiting the spread of microorganisms breaks the infection chain and results in the eventual destruction of the organism. From our discussion of the infectious process, you have learned that it is not necessary to kill all the microorganisms to stop an infection. If you can stop the spread of the microorganisms, you'll break the infection chain and halt the infectious process. If the infectious agents can be confined to their original host, they'll either be destroyed by a combination of medical care and the host's defensive mechanisms or when the host dies and the source of nutrition is gone.

Third, you need to be familiar with aseptic technique terminology. The following table gives some of the more common terms along with their definitions.

Term	Definition
Contamination	Exposure of a sterile item to a microorganism, or the exposure of a clean item to an infectious agent.
Cleaning	Physical removal of organic material or soil from objects; this usually is done using water with or without detergents. Cleaning can be applied to either surgical or medical asepsis.
Disinfection	Describes measures somewhere between cleaning and sterilization. These measures are designed to destroy pathogenic organisms, but they usually do not affect spores. Disinfectants are substances used to carry out disinfection and are used on inanimate objects.
Antiseptics	Substances that reduce the number of microorganisms on living tissue. Antiseptics are associated with medical asepsis.
Sterilization	Designed to destroy or remove all forms of microbial life. Sterilization applies to surgical asepsis only.

With this background knowledge of asepsis, you'll be able to fully understand the levels of asepsis we discuss in the following lessons. Your knowledge and understanding of each level is important, not only for the safety and well-being of your patient but also for yours.

008. Preventing the spread of infection

Early on the standard practice in dealing with people with infectious diseases was to quarantine them along with all members of their household. When quarantine was instituted, no members of the household were allowed to come or go from the place of residence. The US Public Health Service still has the authority to institute quarantine for certain serious infections; in fact you might remember this fact due to the recent worldwide resurgence of the Ebola virus. Now handwashing and a set of preemptive guidelines called *standard precautions* have helped reduce the spread of infection in medical facilities around the globe.

Skin flora

The microorganisms inhabiting skin can be categorized as either "resident" or "transient" flora. *Resident* flora is relatively stable. They can survive for extended periods and are usually identified whenever the skin is cultured. Resident flora is located primarily on the superficial layers of the skin but also can be found in the deeper layers. They tend to cling to the skin and even the superficial types are difficult to remove. Superficial resident flora can sometimes be removed with soap, water, and mechanical activity such as handwashing. Deep flora usually cannot be removed by handwashing techniques but can sometimes be killed or inhibited with antiseptics. Fortunately resident flora is generally low in virulence and cause infections only in patients who are undergoing invasive procedures or who are immunocompromised.

Transient flora is those microorganisms that are picked up through casual contacts. They usually survive less than 24 hours and can be removed *easily* with frequent handwashing techniques.

Transient flora varies from nonpathogenic to highly virulent. In many cases they are picked up from infected patients and are involved in outbreaks of nosocomial infection.

If transient flora remains on the skin for extended periods or in large numbers, they can adjust to their environment and become resident flora. If such flora also happens to be pathogenic, then the individual becomes a carrier for that particular disease. Thorough, frequent handwashing is the only way to prevent transient flora and reduce the possibility of contamination.

Handwashing recommendations

The process of handwashing is the "mechanical removal of microorganisms." Handwashing is the single, most effective means of preventing nosocomial infections. Hands are the most useful tools that medical personnel have. Unfortunately they also are one of the most frequent sources of contamination in a medical facility. Much of that contamination can be linked to poor handwashing techniques. In spite of the dangers associated with infections, such as AIDS or hepatitis, many medical personnel still do not wash their hands at all or do not wash them good enough.

There is no question that hands should be washed, but there is some dispute about how often they should be washed and what agents should be used. Actual handwashing requirements depend on the type, intensity, and duration of patient contact. Though nonlatex gloves are used extensively (as they should be), handwashing after removing disposable nonlatex gloves is still required to ultimately prevent the spread of microorganisms from patient to patient. Handwashing after removing gloves is still needed because the gloves may have become perforated and/or microorganisms may have made their way inside via the opening at the wrist. Below is a simple list of some specific instances when you should definitely wash your hands:

- Before and after providing patient care.
- After removing any type of disposable nonlatex gloves.
- Before and after invasive procedures.
- After prolonged contact with any reservoir of possible infection.
- After situations involving contact with mucous membranes, blood and body fluids, and secretions/excretions.
- After touching, handling, and using inanimate sources likely to be contaminated.
- When visibly soiled.
- After using the restroom.
- Before and after eating.

Understand though that this list of when to wash your hands is just a start; there are many other instances when handwashing is needed to break the chain of infection. Frequent handwashing is the key to reducing nosocomial infections. Many argue though that the act of frequent handwashing causes the skin on the hands to become dry and irritated. For this reason many medical facilities have installed lotion dispensers in restrooms, patient care rooms, and staff areas. *All personnel* should be encouraged to wash their hands anytime there is any question about the necessity for doing so.

As DI technologists you will have the opportunity to enter into highly infected areas. Emergency/urgent-care areas, patient wards, intensive care units (ICU), and surgical suites are areas where you are sent to perform portable radiography. The patients you are imaging are sick and infected; handwashing is just one way to ensure you do not spread something more to them or something they have to other patients, staff members, or yourself. Many of you using this course for upgrade training work or will work at MTFs that have specific infectious disease wards. Patients in these areas are often either infected or colonized (carrying a disease) with a virulent or resistant form of microorganism and are usually highly susceptible to infection because of their wounds, invasive

procedures, or diminished immune system function. For this reason practicing good hand hygiene is of the utmost importance to break the chain of infection!

Recommendations for handwashing techniques and agents depend on the purpose for washing. Also, there isn't a specific minimum handwashing time for all situations. For the most part, the entire handwashing procedure takes give-or-take 60 seconds to complete (from initial wetting to drying). Antimicrobial solutions should be used for handwashing before personnel care for newborns and, when otherwise indicated during their care, between patients in high-risk units, and before personnel care for severely immunocompromised patients.

Handwashing with plain soap, detergents, or antiseptic (antimicrobial) solutions work well by lifting microorganisms from the skin, suspending them in the suds, which allows contaminates to be rinsed off under a stream of water.

To promote frequent and appropriate handwashing, many modern medical facilities have placed sinks and handwashing products in more convenient locations, installed hands-free faucets that can be turned on by motion or by stepping on a floor-mounted peddle, and installed deep sinks that minimize splash. All of which reduce the spread of infectious microorganisms.

Alcohol–based hand rubs

Within the last decade, hand sanitizer (alcohol–based hand rubs) dispensers have become very popular in medical facilities, department stores, and public restrooms alike (fig. 2–7). Alcohol–based hand sanitizing agents use the process of "chemical removal" to prevent the spread of infection/microorganisms. These products have proven to be very effective in killing many common microorganisms, including multidrug-resistant organisms like MRSA and VRE; however, hand sanitizers are *not* effective with bacterial-spore organisms like C. diff. When C. diff is the organism you are trying to remove, handwashing with soap and water is necessary to physically remove contaminates from the hands.

Figure 2-7. Sample hand sanitizer dispenser.

Alcohol–based hand sanitizers are less irritating to skin as most have moisturizers (aloe and vitamin E) added. Though hand-sanitizing agents are very effective, they should not be the only method used to remove microorganisms from the skin on hands. If hands are visibly soiled or contaminated with blood or bodily fluids, washing with soap and water is the required cleansing procedure. Lastly the general rule-of-thumb is that after six uses of a hand sanitizer for chemical removal, health care workers should properly wash their hands using soap and water.

Artificial nails

Artificial fingernails and nail extensions are more likely than natural fingernails to retain bacteria under the nails both before and after handwashing. Because of this, most medical facilities do not allow health care workers with direct patient contact to wear artificial nails. In addition it is important to note that even natural nails should always be groomed to no more than one-fourth inch in length for health care workers providing direct patient care/contact.

Handwashing techniques

Before we discuss specific techniques, we want to reemphasize that these handwashing techniques are designed for medical asepsis. Handwashing for surgical asepsis is called a *surgical scrub* and is much more extensive. In simple terms medical aseptic handwashing is done to decontaminate the hands without contaminating the rest of the body. Surgical aseptic handwashing is done to decontaminate the hands and prevent recontamination by the rest of the body.

NOTE: *Jewelry* is an excellent *source* of contamination and should *not* be worn in patient care areas. A watch should be the only jewelry item you routinely wear, and it should be worn far enough up on your arm so that it does *not* become contaminated or have to be removed when you wash your hands. If long sleeves are worn, roll them up to prevent contamination. For simplicity's sake we'll assume that your hands, wrists, and forearms are bare.

When you become proficient at washing your hands, you will carry out the procedure without considering each step individually. In the previous discussion, the when and why was outlined; therefore, this part of the discussion lays out the proper steps to perform the handwashing technique using a step-by-step approach.

The basic parts of handwashing are wetting, lathering (soaping), scrubbing, rinsing, and drying. To these you can add whatever steps are necessary to turn on and adjust the water, pick up or dispense the soap, and turn off the water. We use the step-by-step approach purely as a mechanism to help you remember the procedure you were taught in technical school. As applicable we include rationale for the procedures:

1. Approach the sink, but do not contaminate your uniform by touching or rubbing against it. If you are fortunate enough to have knee controls or a motion-sensored faucet, turn on and adjust the water so that it is comfortably warm and does not splash out of the sink. If you do not have hand-free controls, use your hands to turn on the water, but remember that the knobs are now contaminated. Adjust the water temperature to lukewarm (for better suds) and ensure the water stream is not so forceful so to splash out of the sink (which would contaminate whatever it hits).
2. Wet your hands thoroughly. Dispense soap into the palm of one of your hands (fig. 2–8).

   NOTE: If you are using bar soap, wet the bar also. To avoid contaminating your upper arms with dirty water, keep your hands lower than your elbows throughout the procedure.

Figure 2–8. Dispensing soap in hand.

3. Lather the soap by working your hands back-and-forth and in a circular motion while rotating your hands to ensure you lather up suds on all aspects of your hands/fingers. Figure 2–9 illustrates lathering up the soap on all sides of your hands.

   NOTE: Lather as far up your arm as may have been contaminated by the procedure you were doing.

Figure 2–9. Lathering up the soap on all sides of your hands

4. Figure 2–10 shows six areas of the hands and fingers to scrub when washing your hands. With the use of friction, scrubbing loosens the flora so that it can be suspended by the soap and carried off by the water. Make sure that you scrub the entire surface of both hands, all fingers including the thumbs, knuckles, sides, fingertips, and beneath the nails. Scrub your hands/fingers for a *minimum* of 20 seconds.

   NOTE: If using a bar of soap and you drop the soap bar, start the procedure over. Remember the sink and everything on it is contaminated. If your *fingernails* are dirty, use a fingernail file or an orange stick to clean them; then *repeat* the lathering and scrubbing steps.

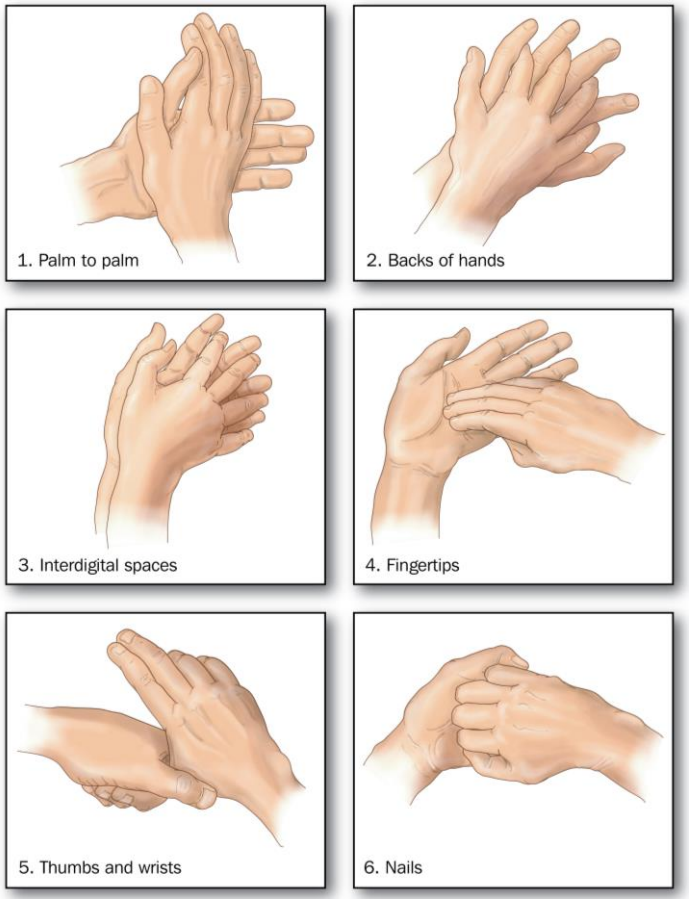

Figure 2–10. Six areas of the hand and fingers to scrub.

5. Completely rinse the soaps/suds from your hands, keeping your hands lower than your elbows (fig. 2–11). Once all suds have been rinsed from your skin, retrieve 1–3 paper towels. Pat your hands dry using the paper towels.

   NOTE: Patting your hands with the towels versus rubbing is preferred as the paper towels tend to fall apart due to the friction caused by rubbing.

Figure 2–11. Completely rinse the soap/suds from hands.

7. Using a paper towel as a barrier (protective device) or your elbow (fig. 2–12), turn off the water if the faucet is not a hands-free device. Drop the towel in the trash, and proceed with your work.

   NOTE: If in a restroom, also use the paper towels to open the door to exit the restroom to avoid contaminating your hands all over again.

Figure 2–12. Using your elbow to shut-off the faucet.

Standard precautions

Standard precautions *reduce* the risk of exposure and transmission of unknown microorganisms from the patient to you, other patients, and staff members. Standard precautions have evolved from a combination of universal precautions introduced in 1985 and body substance precautions introduced in 1987 by the CDC to prevent the spread of blood-borne pathogens. Because patients with Hepatitis B, AIDS, and other blood-borne diseases sometimes go undiagnosed, standard precautions should be used consistently on ***all*** patients.

The basis behind the employment of standard precautions is that when providing patient care, medical workers should assume the patient may have unknown microorganisms on his or her skin or in his or her blood/body fluids; therefore, patient care providers should don protective latex–free disposable gloves for *all* patients and perform handwashing afterwards to effectively break the chain and prevent the spread of infection.

In addition to using latex-free disposable gloves, patient care providers should perform proper handwashing after removing the gloves whenever:

- The patient care provider may come in contact with a patient's blood, bodily fluids, secretions, or mucus membranes.
- The patient care provider has an open cut or abrasion on the skin of the hands as now the integrity of the skin is compromised.
- Handling soiled linen or clothing, urine, feces, vomitus, wound drainage, or used dressings.

If there is the possibility of spattering or splashing of blood or bodily fluids, the addition of a face shield and goggles become required. When providing patient care for patients with respiratory illnesses or infections, have the patient don a mask. When handling sharps (needles or IV catheters), take your time and don't make any abrupt, quick movements to avoid accidentally sticking yourself or a colleague. Always dispose of sharps in an approved sharps container by dropping the sharp into the container instead of placing it in the container. If you have to shave a patient, do so carefully to avoid nicks or cuts on the patient's skin. If a situation arises requiring the performance of cardiopulmonary resuscitation (CPR), always use a barrier device for rescue breaths (mouth-to-mouth resuscitation).

Remember, *standard* precautions are used to *reduce* the risk of transmission of microorganisms from *both* recognized and unrecognized sources of infection in hospitals. This simply means you *may not* know if your patient has an existing infectious process going on within his or her body; therefore, it is important to your health and welfare to use precautions when dealing with any potentially infectious body fluid, whether it is blood, secretions, excretions, nonintact skin, or mucous membranes.

Equipment cleaning

When performing radiography on infectious or immunosuppressed patients, make sure to clean your X-ray unit (whether fixed or mobile) and image receptor with an approved disinfectant (clean *before* for immunosuppressed patients and *after* for infectious patients). Many medical facilities use a germicidal disposable wipe to provide disinfection. This product comes in a variety of versions; therefore, make sure to read the product's label for application, usage, and specific disinfection performance features/purposes. One key characteristic to note when using germicidal disposable wipes is that once the disinfecting liquid is applied by the wipe, the liquid must be allowed to dry naturally to appropriately kill certain microorganisms that may be present. No matter the product used for disinfecting your radiography equipment and X-ray suite, make certain to clean all parts of the equipment the patient came in contact with and any aspect of the X-ray suite the microorganisms may have been directly or indirectly spread to (for example, the collimator knobs, counter-tops, door handles, etc.).

NOTE: Always wear nonlatex gloves when using germicidal wipes.

009. Using transmission-based precautions

Transmission-based precautions are another part of standard precautions. The CDC developed both to prevent the spread of nosocomial infections within medical facilities effectively. Transmission-based precautions employ the use of various barrier items like gloves, impervious gowns, masks, face shields, and the patient's room. When the patient's room is used, a technique called *isolation* blocks transmission of the infectious agent by using walls, doors, and in some cases, even the ventilation

system to prevent the spread of disease. Transmission-based precautions are organized by the method of disease transmission: airborne, droplet, or contact.

Transmission-based precautions

Transmission-based precautions are designed to prevent the spread of microorganisms among patients, personnel, and visitors. Transmission-based precautions successfully break the chain of infection by placing transmission barriers between susceptible individuals and sources of contamination. In most cases the patient is the source of contamination, and the barriers are used to protect everyone else. Such patients are isolated from other patients because they have an extremely contagious (easily spread) disease. On the other side, another class of patients is isolated because they are *highly* susceptible to infection. These patients have a lowered level of resistance because of an injury (i.e., burn), genetic defect, or disease. For these patients isolation means that the barriers are protecting them from the outside world. This is referred to as *reverse isolation*.

Transmission-based precautions and isolation have drastically reduced effects if not all the precautions are followed scrupulously by patients, visitors, and other medical personnel. These precautions may be time-consuming, inconvenient, and sometimes difficult to work with but must be followed. At times, the concept of *clean* versus *dirty* is difficult for some people to understand; this is especially the case when patients aren't showing any visible signs of infection or contamination.

When a patient is infected with highly transmissible pathogens, transmission-based precautions and isolation techniques are put into effect by the physician/medical care team. There are three types of transmission-based precautions: airborne, droplet, and contact precautions. Whether used alone or together, the CDC recommends using all transmission-based precautions in conjunction with standard precautions.

Transmission	Precautions
Airborne	To reduce the risk of spreading infectious agents by the "airborne" route: • Place the patient in a private room that has monitored, negative air pressure. • Keep the door to the room closed, and wear protective respiratory equipment (mask). Infectious agents that are spread through the air can be dispersed by air currents. Tuberculosis, varicella, and measles are diseases spread in this manner.
Droplet	Patients with infectious agents that can be spread by coughing, sneezing, or talking are placed in droplet precautions isolation. Wear masks when working within three feet of these patients. Bacterial infections spread by droplets include diphtheria, mycoplasma pneumonia, pertussis, pneumonic plague, streptococcal pharyngitis, pneumonia, and scarlet fever. Viral infections include adenovirus, influenza, mumps, parvovirus, and rubella.
Contact	Infections spread by way of direct contact with patients or indirect contact via contaminated objects require the use of contact precautions. The patient must be placed in a private room or with another patient who has the same infection. Your personal precautions include: • Wear of gloves and an impervious gown is required upon entering the patient's room to provide patient care. • Remove the gloves and gown prior to leaving the patient's environment. • Wash your hands with an antimicrobial agent. Some of the more commonly seen diseases within this area of precaution include MRSA, VRE, C. diff, hepatitis A, herpes simplex, pediculosis, scabies, and viral conjunctivitis.

A combination of airborne and contact transmission-based precautions is used to prevent two common viruses: the corona virus that causes the severe acute respiratory syndrome (SARS) and the varicella virus that causes chicken pox. Health care workers who have not had chicken pox should

avoid exposure to patients with the disease. On the contrary if a health care worker has had chicken pox, they need not wear a mask when around this type of patient.

Physical barriers

The physical barriers of isolation fundamentals include the patient unit itself, masks, gowns, gloves, eye protection/face shields, and equipment. Let's look at each one.

Patient unit

The most effective type of isolation unit is a private room. Here the patient is physically separated from other patients, and personnel are more apt to remember to use the appropriate isolation attire and perform handwashing before going on to other patients. Private rooms are typically equipped with handwashing, toilet, and bathing facilities for patients to use so they do not have to leave their private (isolation) room. Some isolation rooms in modern facilities also have an anteroom (waiting room) that serves to separate the contaminated area further from just beyond the isolation room door. As an *alternative* to an anteroom, an *isolation cart* can be placed just outside the door to the isolation unit. This cart should have all the supplies (barriers) that are needed for the patient's particular transmission-based precautions. The cart is restocked as needed and kept *outside* the room. All trash and soiled linen is disposed of in the room and only removed by appropriately trained housekeeping staff. As a final note, there should be a sign on the door specifying the type of isolation and precautions to take.

In some instances (e.g., patients with infectious airborne pathogens) an isolation room with negative pressure ventilation is recommended. This ventilation creates a pressure difference between the room and the outside so that air is drawn into the room rather than expelled when the door is opened. This system should provide at least six air changes per hour and should be discharged outdoors.

Masks

Wear masks to prevent transmission of airborne infectious agents. They protect the wearer from inhaling large particle aerosols (droplets) that are transmitted by close contact and generally travel only short distances (three feet) and small particle aerosols (droplet nuclei) that remain suspended in air and travel longer distances. Masks also prevent transmission of some infections that are spread by direct contact with mucous membranes, because masks discourage personnel from touching their own mucous membranes (eyes, nose, and mouth). Always wear what is approved and provided by your facility; however, in general, the high-efficiency disposable masks are more effective than cotton gauze or paper tissue masks.

If the infection is transmitted by large-particle aerosols, you need a mask only if you are working close to the patient. If the infection is transmitted over *longer* distances, don a mask *before* you enter the room and remove it and drop it in the trash just *prior* to leaving the room as it is now contaminated and should *not* be taken out of the room.

Impervious gowns

Use impervious gowns to prevent contamination of your clothes when caring for patients and protect your skin from blood and body fluid exposures. A gown is required whenever you may come in contact with the patient or other contaminated objects. Remember when gowns are worn to prevent the spread of infection, you wear them only once and discard them before leaving the patient's room or X-ray suite.

To be effective, your gown should cover as much of your clothes as possible and not have any rips, holes, or tears, and it should be impermeable to liquids. When you are putting it on, try to overlap the back as much as possible. You'll probably not contaminate your back anyway, but a little insurance doesn't hurt. Secure the gown at the neck and waist. When you finish your patient care tasks, remove the gown, taking care not to contaminate your uniform as you remove it—turn it inside out, and drop it in the trash. *Wash your hands before you leave!!*

Gloves

You need to wear gloves to do the following:

1. Provide a protective barrier and prevent gross contamination of the hands when touching blood, body fluids, secretions, excretions, mucous membranes, and nonintact skin.
2. Reduce the likelihood that microorganisms present on the hands of personnel will be transmitted to patients during invasive or other patient care procedures that involve touching a patient's mucous membranes and nonintact skin.
3. Reduce the likelihood that hands of personnel contaminated with microorganisms from a patient or fomites can transmit these organisms to another patient. A fomite is an infectious object.

Gloves are either sterile or nonsterile for isolation, depending on the type of isolation or the procedure being done. If you are doing a sterile procedure or working with an immunosuppressed patient, for example, wear sterile gloves. For routine care you can wear nonsterile-nonlatex gloves. The wear of gloves does *not* eliminate the need for handwashing! You'll still accumulate microorganisms beneath the gloves, and there is always a possibility the gloves could be torn or punctured.

When you take off your gloves, you need to pay attention so you do not touch the contaminated outside portion of one glove with the inside of the other glove (or your bare hand). Your bare hand should only touch the inside of either contaminated glove. Take your gloves off before you leave the area and drop them in the trash. If your gloves become heavily contaminated during the procedure, change them before continuing. Make sure to wash your hands properly after removing your gloves.

Eye protection and face shields

The Occupational Safety and Health Administration (OSHA) mandate wearing goggles or face shields in certain circumstances to prevent the transmission of blood-borne pathogens. The purpose of wearing such protective equipment is to protect your eyes and the mucous membranes of your mouth when splattering or splashing of blood or body fluids is possible.

Equipment

If disposable equipment becomes contaminated, bag, label, and dispose of it in accordance with local policy. When nondisposable equipment becomes contaminated, clean it, bag it, and send it to Central Sterile Supply for disinfection and processing. No special precautions are needed for sphygmomanometers and stethoscopes, unless they become contaminated. If so they are dealt with in the same manner as other contaminated equipment. Take special care with needles, syringes, scalpel blades, and other items that may be contaminated with the patient's blood. Place such items in an appropriate biohazard storage device. When it is full, the device should be bagged, labeled, and disposed of according to infection control and US Environmental Protection Agency (EPA) guidelines.

Radiography of isolation patients

When radiography of isolation patients is required, it is best to approach the task as a two-technologist procedure. One technologist is referred to as the "clean" tech and the other the "dirty" tech. The "clean" technologist handles the equipment (whether fixed or mobile) while the "dirty" technologist handles the patient and the covered image receptor (IR). To successfully complete this two-person procedure, it is important to reiterate that the "dirty" tech never touches the patient and the equipment (or uncovered IR) and the "clean" tech never touches the patient, bed, wheelchair, the covered IR, or anything the patient may have touched/contaminated.

Mobile radiography of isolation patients

Upon arriving at the patient's isolation room, check with the patient's nurse prior to entering for any last minute instructions or information regarding the patient's condition. Before entering the isolation

room, place the IR in a plastic bag (specifically designed to cover the IR) or a pillowcase. Remove any jewelry to include your watch so the articles are not contaminated. Don the protective gear as designated by the transmission-based precaution sign posted on the door of the patient's room.

NOTE: Remember to don your lead gown first, then put the impervious isolation gown on overtop of the lead gown.

Use the clean/dirty technique explained previously; allow the "clean" tech to move the equipment into the correct position next to, but not touching, the patient's bed. The "dirty" tech then positions the patient and the covered IR. The "clean" tech adjusts the tube head while avoiding contact with the patient or bed. After the exposure is made, the "clean" tech backs the equipment away from the bed, and the "dirty" tech retrieves the IR from behind/under the patient. Once the IR is retrieved, the "dirty" tech presents the IR to the "clean" tech in a manner that they can reach inside the bag (or pillowcase) to retrieve the IR without becoming contaminated. At the door but still inside the room, both techs remove all donned protective gear and place it in a biohazard bag within the room. Upon exiting the room with the mobile unit and IR, both items are then wiped thoroughly with a disinfectant. Last but not least, the process is completed with the techs washing their hands.

Radiology of isolation patients in the DI department

When a patient must be brought to DI for a radiograph or computed tomography (CT) examination, special coordination is necessary to ensure an isolation patient spends as little time in DI as possible. When you receive a phone call from the ICU or ward regarding an isolation patient who needs to be brought to DI for an X-ray, you should get the patient's type of isolation (airborne, droplet, or contact). In addition this information should be given to your floor manager, so they can designate an X-ray suite to be set aside for performing the exam. A suite is set aside so that the isolation patient can be transported directly from his or her room to the X-ray suite without stopping in the waiting area or hallway. This is very important because if the isolation patient is forced to wait in the hallway or waiting room, he or she is potentially contaminating other patients or inanimate objects.

Prepare the room by removing any inanimate objects not needed for the exam from the X-ray suite, placing a sheet on the X-ray table, and whenever possible, using the two-person technique just as described for performance of a mobile radiographic exam. Both techs don the appropriate isolation attire (e.g., gown, mask, gloves, etc.). The "dirty" tech assists/positions the patient for the examination. The "clean" tech adjusts the equipment, IR, and makes the exposure. Use the two-person technique to minimize the exposure of the infectious agent to additional people and objects. When the exam is complete and the patient is returned to his or her bed/wheelchair, remove the isolation attire and begin cleaning the room with your facilities-approved disinfectant. Of course the final step is to wash your hands properly as previously described. As well most medical facilities require housekeepers to professionally clean the room and remove all infected linen/trash. Make sure you know and follow your facilities' procedures for disinfecting your X-ray suite prior to continuing patient care on other noninfected patients.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

007. Preventive measures for nosocomial infections

1. What is a nosocomial infection?

2. What factors contribute to the development of a nosocomial infection?

3. Name two types of treatment that are among the leading causes of nosocomial infections.

4. How do staff members frequently contribute to nosocomial infections?

5. What is the *most* basic and important preventive measure you can perform to fight the spread of infection?

6. What are the *best* personal defenses against infection?

7. What does the term *asepsis* mean?

8. Why can asepsis be achieved on inanimate objects but not on people?

9. Why is it unnecessary to kill all the microorganisms to stop the infectious process?

10. What procedure is designed to destroy pathogens but usually does *not* affect spores?

11. What is the difference between disinfectants and antiseptics?

008 Preventing the spread of infection

1. What is the difference between resident and transient flora?

2. What is the single, *most* effective means of preventing nosocomial infections?

3. What factors are used to determine handwashing requirements?

4. Why should you wash your hands even if you wear gloves?

5. When should antimicrobial solutions be used for handwashing?

6. How does using plain soap work well to remove microorganisms from the skin?

7. Alcohol-based hand sanitizing agents use the process of what to prevent the spread of infection?

8. How does the purpose for medical aseptic handwashing differ from the purpose for surgical aseptic handwashing?

9. What is the *minimum* amount of time you should scrub your hands/fingers when washing your hands?

10. What is the basis behind the employment of standard precautions when providing patient care?

009. Using transmission-based precautions

1. What is the purpose of transmission-based precautions?

2. Why are transmission-based precautions successful in breaking the chain of infection?

3. What are the three types of transmission-based precautions?

4. Match the type of transmission-based precaution in column B that would be used with the appropriate condition/mechanism of transmission in column A. Items in column B may be used once, more than once, or in combination with another.

Column A	*Column B*
____ (1) A patient has MRSA.	a. Airborne.
____ (2) Wear of a protective respiratory mask is required.	b. Droplet.
____ (3) When infectious agents are spread by coughing, sneezing, or talking and working within three feet of the patient.	c. Contact.
____ (4) A patient has chicken pox (varicella virus).	
____ (5) A patient is in a private room and the wear of gloves and an impervious gown is required.	
____ (6) You are imaging a patient with Tuberculosis.	

5. Why is a private room the most effective type of isolation unit?

6. When is it recommended for an isolation room to use negative air pressure?

7. How do masks protect the wearer?

8. When should you put on and take off a mask?

9. Why should you wear an impervious gown as a barrier device for contact precautions?

10. What are three reasons gloves are worn?

11. When is it important to wear eye protection and a face shield?

12. Explain the two-technologist approach to performing an exam on an isolation patient.

Answers to Self-Test Questions

005

1. Infectious agent, reservoir, portal of exit, mode of transmission, portal of entry, and susceptible host.
2. By producing toxic substances or destroying parts of the cell they have invaded.
3. Normal flora for that area.
4. Normal flora becomes pathogenic and causes disease.
5. Commensalism.
6. Carriers are asymptomatic but are still able to pass the pathogen onto other, more susceptible individuals.
7. When one of the infectious agents invades the body through one of the portals of entry, finds an area that meets its needs, and begins to grow and reproduce itself.
8. Type of organism involved and condition of the host.
9. Aggressiveness and toxicity.
10. Spherical, rod, and spiral.
11. Yeasts and molds.
12. They assume a rounded shape and secrete a protective cyst-like covering.
13. Viruses.
14. A virus lacks a cell wall and a district nuclear structure.

15. Adult, egg, and larval (immature) stages.
16. Larval.

006

1. A favorable environment and source of nutrition.
2. Always assume the potential reservoirs are contaminated.
3. The capability for infectious agents to be communicated from one person to another.
4. Mouth, nose, anus, urethral meatus, and occasionally, the eyes.
5. Indirect contact is touching an object that has been in contact with the reservoir.
6. By food, beverages, drugs or medications, blood, or intravenous (IV) lines.
7. Infectious agents or spores of infectious agents become suspended in the air in dust particles, aerosols, sprays, or even droplets.
8. They are unable to get past the skin.
9. It indicates that conditions exist that will allow infectious microorganisms (agents) to penetrate the host's defenses.
10. Natural immunity.
11. By having the disease (naturally acquired active immunity), receiving immunizations (artificially acquired active immunity), or receiving antibodies (passive immunity).
12. Age, sex, race, environment, state of health, disease processes and injuries, medications and treatments, and exposure and susceptibility to microorganisms.
13. When an infectious agent is able to overcome the host's defenses and find a favorable location for growth and multiplication.

007

1. Nosocomial infections are defined as infections that patients acquire as a result of treatment in a medical facility.
2. The patient condition, type of treatment/ therapy, exposure, or employee carelessness.
3. Urinary catheterization and IV lines.
4. By being careless, they may accidentally contaminate equipment/supplies and then use the same equipment/supplies on a patient.
5. Washing your hands.
6. Good health, proper hygiene, and natural barriers.
7. Asepsis means the absence of infection.
8. The human body is relatively fragile, and it is not possible to kill the microorganisms on our bodies without damaging ourselves in the process.
9. By stopping the spread of microorganisms, you'll break the infection chain and halt the infectious process.
10. Disinfection.
11. Disinfectants are designed to destroy pathogenic organisms and are used on inanimate objects. Antiseptics are designed to reduce microorganisms on living tissue.

008

1. Resident flora has a long life span, are found on superficial and deep skin layers, and adhere very well to the skin. Transient flora has a short life span, occupy the superficial layers of the skin, and can be removed easily with frequent handwashing.
2. Handwashing.
3. Type, intensity, and duration of patient contact.
4. Because the gloves may have become perforated and/or microorganisms may have made their way inside via the opening at the wrist.
5. Before personnel care for newborns and, when otherwise indicated during their care, between patients in high-risk units, and before personnel care for severely immunocompromised patients.

6. By lifting microorganisms from the skin, suspending them in the suds, which allows contaminates to be rinsed off under a stream of water.
7. Chemical removal.
8. Medical aseptic handwashing is done to decontaminate the hands without contaminating the rest of the body. Surgical aseptic handwashing is done to decontaminate the hands and prevent their recontamination by the rest of the body.
9. 20 seconds.
10. Medical workers should assume patients may have unknown microorganisms on their skin or in their blood/body fluids; therefore, patient care providers should don protective latex–free disposable gloves for all patients and perform handwashing afterwards to effectively break the chain and prevent the spread of infection.

009

1. Prevent the spread of microorganisms among patients, personnel, and visitors.
2. Because transmission barriers are placed between susceptible individuals and sources of contamination.
3. Airborne, droplet, and contact precautions.
4. (1) c.
   (2) a.
   (3) b.
   (4) a, c.
   (5) c.
   (6) a.
5. The patient is physically separated from other patients, and personnel are more apt to remember to use the appropriate isolation attire and perform handwashing before going on to other patients.
6. For patients with infectious airborne pathogens.
7. They protect the wearer from inhaling large particle aerosols (droplets) that are transmitted by close contact and generally travel only short distances (three feet) and small particle aerosols (droplet nuclei) that remain suspended in air and travel longer distances. Masks also prevent transmission of some infections that are spread by direct contact with mucous membranes, because masks discourage personnel from touching their own mucous membranes (eyes, nose, and mouth).
8. Don a mask before you enter the room and remove it and drop it in the trash just prior to leaving the room as it is now contaminated and should not be taken out of the room.
9. To prevent contamination of your clothes when caring for patients and protect your skin from blood and body fluid exposures.
10. (1) To provide a protective barrier and prevent gross contamination of the hands when touching blood, body fluids, secretions, excretions, mucous membranes, and nonintact skin; (2) To reduce the likelihood that microorganisms present on the hands of personnel will be transmitted to patients during invasive or other patient care procedures that involve touching a patient's mucous membranes and nonintact skin; and (3) To reduce the likelihood that hands of personnel contaminated with microorganisms from a patient or fomites can transmit these organisms to another patient.
11. When splattering or splashing of blood or body fluids is possible.
12. One technologist is referred to as the "clean" tech and the other the "dirty" tech. The "clean" technologist handles the equipment (whether fixed or mobile) while the "dirty" technologist handles the patient and the IR.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

12. (005) What term is used to refer to organisms that *cause* infection and disease?
    a. Septic.
    b. Antigen.
    c. Pathogen.
    d. Malicious.

13. (005) Which term is used to describe the host's ability to develop a tolerance for the invading organism?
    a. Carrier.
    b. Normal flora.
    c. Infectious state.
    d. Commensalism.

14. (005) Which type of bacteria gets its nutrition from other living sources?
    a. Aerobic.
    b. Flagella.
    c. Parasite.
    d. Anaerobic.

15. (005) Which type of microorganism survives by entering a host cell and altering its reproductive structures to produce additional microorganisms?
    a. Fungi.
    b. Viruses.
    c. Bacteria.
    d. Helminths.

16. (006) Which mode of transmission for infectious agents involves transmission by insects or rodents?
    a. Vehicle.
    b. Vectors
    c. Droplet.
    d. Contact.

17. (006) Which immune response occurs as a result of actually having the disease?
    a. Natural immunity.
    b. Passive immunity.
    c. Acquired immunity.
    d. Interferon immunity.

18. (007) Which patients would have the greatest risk for development of a nosocomial infection?
    a. Obstetrical.
    b. Orthopedic.
    c. Chemotherapy.
    d. Physical therapy.

19. (007) What is the *most* basic and important preventive measure to prevent nosocomial infections?
    a. Disinfection.
    b. Sterilization.
    c. Handwashing.
    d. Immunizations.

20. (007) Which medical term means the absence of infection?
    a. Sepsis.
    b. Asepsis.
    c. Antiseptic.
    d. Antimicrobial.

21. (007) Which substance is used to reduce the number of microorganisms on living tissue?
    a. Antitoxin.
    b. Antiseptic.
    c. Disinfectant.
    d. Anticoagulant.

22. (007) What method of aseptic technique describes the physical removal of organisms from an object?
    a. Cleaning.
    b. Scrubbing.
    c. Sterilization.
    d. Disinfection.

23. (008) Which type of skin flora is removed easily with frequent handwashing techniques?
    a. Deep.
    b. Resident.
    c. Transient.
    d. Superficial.

24. (008) When using appropriate handwashing techniques, after cleaning your fingernails with an orange stick, you should
    a. repeat the lathering and scrubbing steps.
    b. continue the scrub for a minimum of 10 seconds.
    c. rinse your hands and pat them dry with a paper towel.
    d. rinse the soap off and drop the soap bar in the soap dish.

25. (008) Which statement *best* explains the purpose of the standard precautions recommended by the Centers for Disease Control?
    a. Reduce the risk of transmission of bloodborne pathogens.
    b. Reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in hospitals.
    c. Prevent the spread of infectious agents by interfering with the organisms known method of transmission.
    d. Prevent the spread of infectious agents by interfering with the organisms known method of reproduction.

26. (008) When should you disinfect a mobile X-ray unit for an immunosuppressed patient?
    a. Before and after performing the exam.
    b. Before performing the exam.
    c. After performing the exam.
    d. Disinfection is not required.

27. (009) Patients who are *highly* susceptible to infection are placed in what type of isolation?
    a. Airborne.
    b. Droplet.
    c. Contact.
    d. Reverse.

28. (009) Which type of transmission-based precaution requires the patient to be placed in a monitored, negative air pressure room?
    a. Airborne.
    b. Droplet.
    c. Contact.
    d. All of the above.

29. (009) If you enter an isolation unit, you put the mask on
    a. before entering, and take it off after leaving.
    b. before entering, and take it off before leaving.
    c. after entering the unit, and take it off before leaving.
    d. after entering the unit, and take it off after leaving.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Administrative Functions of Diagnostic Imaging

AS YOU ADVANCE in the DI career field, you'll be rewarded with promotions and increased responsibilities. Often these additional responsibilities mean you'll be tasked with disposition of old radiology records or possibly be the point-of-contact for your department's supply and equipment needs. This unit introduces you to some of the administrative additional duties and responsibilities you may encounter the longer you stay in DI. The discussion includes sections on film library functions and supply and property procedures. We begin with film library functions.

3–1. Film Library Functions

Nothing can impair the function of a radiology department more than poorly kept records. A big problem with any records system is the inability to find a document when it is needed. In a radiology department, this problem takes on added significance when prior images cannot be located for use as comparison images. At most facilities most all images are now stored digitally, so the film library footprint is getting smaller and smaller; however, some AF locations are still maintaining mammography images and images being retained because of tobacco or asbestos litigation. In situations as such, the DI department must maintain a reliable records system.

010. Film filing, loaning, and transfer procedures

An organized system of storage and retrieval for radiographs in your department's film library is essential for follow-up care. This lesson encompasses some of the tasks performed in the DI film library (file room).

Filing radiographs

Prior to the electronic age of DI, hardcopy radiographs and radiographic reports were stored in the patient's film file envelope, otherwise referred to as a film jacket or master jacket. Within the film file envelope, subfolders were used to group similar radiographs (i.e., chest, bone, CT, etc.). Film file envelopes were then filed according to the military sponsor's SSN using a system referred to as the "terminal–digit filing system." Color coded stickers (fig. 3–1) were placed on the end of the master jacket to allow for easy identification of the primary number portion of the patient's (sponsor's) SSN. This color coding technique made it easy to spot misfiled film folders within the shelving units. The film file is the set of all patient folders filed together. The film file was cut off on the last day of the calendar year (31

Figure 3–1. Color-coded film file envelopes.

December) and a new file was established on 1 January of each year. Today many DI departments still maintain historical film file envelopes; however, no new envelopes are typically created due to the onset of the digital age of DI over the past 10 years.

Terminal-digit filing

Terminal-digit filing is the preferred system for filing records, including film file envelopes. As stated before the system is based on the SSN of the patient (or sponsor, if the patient is a dependent). Using the SSN 900–45–6789 as an example, each SSN is broken down as follows:

900 –	45 –	67 –	89
Second-part tertiary number	*First-part tertiary number*	*Secondary number*	*Primary number*

When filing a film file folder, follow these steps for filing a radiographic film folder: first file the film folder according to the primary number, then the secondary number, then first-part tertiary number, and finally the second-part tertiary number of the patient/sponsor's SSN. For example the following four SSNs have been aligned correctly:

906–94–54–66

923–10–55–66

936–56–56–66

901–31–60–66

All four folders are filed in the 66 section because each primary number is 66. In addition the four folders are aligned according to their secondary numbers, which you can see, are 54, 55, 56, and 60. The four numbers listed above are correctly aligned. Notice that the first and second parts of the tertiary numbers in the four SSNs listed have no pattern whatsoever. The reason for this is under the terminal–digit filing system you only align the secondary numbers if the primary numbers are the same; likewise you only align the first part of the tertiary numbers if the secondary numbers are the same, etc.

To further demonstrate this filing technique, the following SSNs are arranged correctly using the terminal–digit filing system and the steps of filing hierarchy stated above.

a. 906–94–54–66

b. 923–10–55–66

c. 923–11–55–66

d. 936–56–56–66

e. 935–57–56–66

f. 936–57–56–66

g. 901–31–60–66

Now take a closer look at these seven folders. Because the primary numbers are all 66, they would be filed in the section labeled "66." Of the seven secondary numbers *b* and *c* are identical (55), so we must look to the first parts of the tertiary numbers, which are 10 and 11. Obviously 10 comes before 11. Three other secondary numbers *d*, *e*, and *f* are also identical (56), so we must look once again at the first parts of the tertiary numbers. In this case *d* is 56 and *e* and *f* are 57. Obviously 56 comes first. Now since we have two first-part tertiary numbers that are identical (57), we must look to the second part of the tertiary numbers. As you can see those numbers are 935 and 936 and are correctly aligned.

Prefix codes

Because each dependent's folder is marked with the sponsor's SSN, a two-digit prefix code is added to patients' film file numbers (SSN) to further assist in identifying folders marked with the same SSN. The codes listed in the following table identify the status of the individual (patient). For example the first dependent child is given the prefix 01, while the first dependent spouse is given a prefix of 30.

Defense Enrollment Eligibility Reporting System (DEERS) Authorized Prefix Codes	
Prefix Code	**Patient Designation**
01–19	Dependent children of sponsor(listed in succession)
20	Active duty and retired military personnel
30–39	First through tenth spouse/former spouse
40	Mother, step-mother of sponsor
45	Father, step-father of sponsor
50	Mother in law of sponsor
55	Father in law of sponsor
60–69	Other authorized dependents
90–95	Beneficiary authorized by statute
98	Civilian emergency
102	All others, not elsewhere classified

Using these codes will minimize confusion between files of the military members and their dependents, especially in cases where the first names are similar or the same (always pay close attention to "juniors"). You must remember that the same file number (SSN) is used for the military member and all of his or her dependents.

Locating misplaced files

When individuals do not follow the terminal–digit filing system as it is designed, film folders get misplaced or lost. When films are misplaced or lost, a patient's image/diagnosis may be delayed or, worse yet, interpreted incorrectly. When a film folder is not where it is supposed to be, there are a few steps that can be employed to help find the misplaced file folder.

1. Check 20 film folders to each side of where the film folder is supposed to be located.
2. Look for color-coded labels that are out of place with others in the same group.
3. Possible number dyslexia; for example if the primary number of the SSN is 78, check the 87 group.

Film-loaning and transfer procedures

Procedures for loaning or transferring hard-copy radiographs were an important part of DI film libraries over the years; however, in the digital age, technology has made these procedures much easier. Many times patients are seen by doctors outside of the MTF, but when diagnostic images are requested by those outside providers, the patient still may choose to use the DI services at your location. Then upon completion of the DI study, the patient places a request with the film library in your department for digital copies of his or her images.

The steps for copying digital images to a compact disk (CD) vary from location to location based on the type of CD burner and software. Here are some typical steps for loaning or transferring digital images:

1. Patient places a request at the film library for copies of all (or specific studies) of his or her radiographic images.

2. Log the request in a computer system or similar mechanism to track the work request.
3. Using your picture archiving computer system (PACS), locate the requested images on the electronic hard drives.
4. Place a blank CD in the CD writer slot of the burner or a government owned personal computer (PC).
5. Depending upon the type of software, select and copy (or drag and drop) the specific image(s) from the digital folder to the CD with a universal viewer program allowing the radiographic images to be viewed on any PC.
6. The CD is labeled with the patient's name, the servicing MTF name and phone number, and a privacy act statement.
7. Creation of the CD is recorded in the tracking mechanism to show the job request has been completed.
8. The CD of images is given to the patient for his or her own use and/or the physician's use.

NOTE: You should seek out on-the-job training (OJT) regarding the specific steps and procedures for burning images to CD at your location.

With film, accountability of radiographs was a big deal because once a radiograph was lost; the only option was to take the image again, which exposed the patient to more ionizing radiation and, in turn, used up more department resources (film, processing chemicals, and manpower). Hard-copy films checked out in the past were required to be returned to the servicing MTF within 5–10 days as the images were considered US government property. Now, if a patient wants to check out hardcopy films, the films are made into electronic format by way of a film digitizer (fig. 3–2) and then burned to a CD for the patient to use as they please. Film digitizing is the process by which hardcopy X-ray films are electronically scanned, and the images are made into an electronic format to be stored on a PACS hard-drive. Furthermore if the patient wants the hardcopy originals, the patient is typically allowed to sign out the original radiographs once the hard-copy images have been digitized into PACS.

Figure 3–2. Sample film digitizing unit.

The exception to allowing original hard-copy images to be checked out is in the case of sensitive (medical-legal) images. In other words if a lawsuit has been filed and proceedings are pending in relationship to a patient or type of medical condition (i.e., cancer and tobacco litigation), then the originals are not allowed to be checked out unless authorized by the medical legal office. In this case the patient (or requesting entity) would be allowed to have a CD copy of the images.

011. Maintenance of radiologic film files

Properly maintain radiology file records according to published guidance. The AF Records Information Management System (AFRIMS) website is located on the USAF Portal; AFRIMS is the source for maintaining all types of radiologic records (files).

Air Force Records Information Management System

The AFRIMS website is a one-stop shop for information pertaining to the maintenance of all types of Air Force records. To access the information, go to the following link: https://www.my.af.mil/afrims/afrims/afrims/rims.cfm

Once on the AFRIMS webpage, hover your PC mouse arrow over the "RDS" heading; a drop-down of subheading will appear. Select "Search" with one left-click using your PC mouse and then, type "radiology" in the keywords field. The guidance you are looking for is under the heading, "Results from tables"; it is series 44 table 03 (or 44–03), Radiology Records. Place your mouse arrow over the 44–03 and left-click once. You have now accessed the current radiology records disposition schedule. The following maintenance and disposition information is taken from the AFRIMS website, table 44–03 for a variety of radiologic film file types.

Maintenance and disposition of radiology film files

Table 44–03: MEDICAL—RADIOLOGY RECORDS

TABLE & RULE: T 44–03 R 10.00 **CURRENT:** Yes

AUTHORITY: N1–330–01–02 **FROZEN RECORD:** NO

TITLE: Diagnosis X-Ray Film **DATE MODIFIED:** 16/Jun/2005

COLUMN B CONSISTING OF: X-ray and cardiac catheterization film

COLUMN C WHICH ARE: exposed during periodic physical examinations, examinations for flight, promotion, or other special training. Not including entrance or separation x-rays.

COLUMN D DISPOSITION: Destroy five years after the end of the calendar year in which last film was taken.

NOTES:

212 Electronic copies created using electronic mail and word processing: Destroy paper after recordkeeping copy has been created and filed or when no longer needed for revision, dissemination, or reference, whichever is later.

213 Electronic systems that replace temporary hard copy records: Destroy on expiration of the retention period previously approved for the corresponding hard copy records.

214 Electronic systems that supplement temporary hard copy records where the hard copy records are retained to meet recordkeeping requirements: Destroy when the agency determines that the electronic records are superseded, obsolete, or no longer needed for administrative, legal, audit, or other operational purposes.

Mammography image files

TABLE & RULE: T 44–03 R 14.00 **CURRENT:** YES

AUTHORITY: N1–330–01–02 **FROZEN RECORD:** NO

TITLE: Mammograms/Breast Ultrasound **DATE MODIFIED:** 16/Jun/2005

COLUMN B CONSISTING OF: X-rays and ultrasounds taken of breast tissue

COLUMN C WHICH ARE: for purposes of detecting breast disease

COLUMN D DISPOSITION: Destroy 10 years after the end of the calendar year of the last film.

NOTES:

212 Electronic copies created using electronic mail and word processing: Destroy paper after recordkeeping copy has been created and filed or when no longer needed for revision, dissemination, or reference, whichever is later.

213 Electronic systems that replace temporary hard copy records: Destroy on expiration of the retention period previously approved for the corresponding hard copy records.

214 Electronic systems that supplement temporary hard copy records where the hard copy records are retained to meet recordkeeping requirements: Destroy when the agency determines that the electronic records are superseded, obsolete, or no longer needed for administrative, legal, audit, or other operational purposes.

658 The medical facility that forwards the medical health records to NPRC will remove the mammograms and retain them until scheduled for destruction.

Occupational image files

TABLE & RULE: T 44–03 R 09.00 **CURRENT:** YES

AUTHORITY: N1–330–01–02 **FROZEN RECORD:** NO

TITLE: Negative Military Occupational Illness X-Ray Film **DATE MODIFIED:** 16/Jun/2005

COLUMN B CONSISTING OF: X-ray file

COLUMN C WHICH ARE: taken for medical surveillance of personnel exposed to toxic substances or harmful physical agents in their work environment where no evidence of occupational illness has been found

COLUMN D DISPOSITION: Destroy five years after the end of the calendar year of the date of the last x-ray.

NOTE:

214 Electronic systems that supplement temporary hard copy records where the hard copy records are retained to meet recordkeeping requirements: Destroy when the agency determines that the electronic records are superseded, obsolete, or no longer needed for administrative, legal, audit, or other operational purposes.

Final type image files

TABLE & RULE: T 44–03 R 01.00 **CURRENT:** YES

AUTHORITY: N1–330–01–02 **FROZEN RECORD:** NO

TITLE: Entrance and Separation X-Ray Film **DATE MODIFIED:** 16/Jun/2005

COLUMN B CONSISTING OF: entrance and separation x-ray film

COLUMN C WHICH ARE: X-ray film exposed during medical examinations of civilians who are inducted, enlisted, appointed or commissioned in the active military service or in the Reserves and National Guard. X-ray film exposed during medical examinations of military personnel who reenlist or receive appointments as commissioned or warrant officers. X-ray film exposed during a release from active duty or separation examination.

COLUMN D DISPOSITION: Retain no longer than four months after creation.

NOTES:

212 Electronic copies created using electronic mail and word processing: Destroy paper after recordkeeping copy has been created and filed or when no longer needed for revision, dissemination, or reference, whichever is later.

213 Electronic systems that replace temporary hard copy records: Destroy on expiration of the retention period previously approved for the corresponding hard copy records.

214 Electronic systems that supplement temporary hard copy records where the hard copy records are retained to meet recordkeeping requirements: Destroy when the agency determines that the electronic records are superseded, obsolete, or no longer needed for administrative, legal, audit, or other operational purposes.

667 Retain X-rays, along with all additional films taken as a result of questionable anomalies that do not result in an application being rejected. Retire X-ray film to NPRC 111 Winnebago Street, St. Louis, MO 63118. VA is authorized custodian of records after transfer (VA schedule RCS VB–1, Part 1, Section XIII (13–061.100). Destroy in accordance with current VA disposition instructions.

Teaching image files

TABLE & RULE: T 44–03 R 11.00 **CURRENT:** YES

AUTHORITY: N1–AFU–89–18 **FROZEN RECORD:** NO

TITLE: X-Rays of Unusual Interest or Those Selected for Teaching Purposes **DATE MODIFIED:** 16/Jun/2005

COLUMN B CONSISTING OF: X-rays of unusual interest or those selected for teaching purposes

COLUMN C WHICH ARE: oversized and will not fit in the medical folder

COLUMN D DISPOSITION: Destroy/salvage after five years, or when of no further value, whichever is later (Exception: refile rule nine X-rays in appropriate medical folder or holding area).

NOTES:

212 Electronic copies created using electronic mail and word processing: Destroy paper after recordkeeping copy has been created and filed or when no longer needed for revision, dissemination, or reference, whichever is later.

213 Electronic systems that replace temporary hard copy records: Destroy on expiration of the retention period previously approved for the corresponding hard copy records.

214 Electronic systems that supplement temporary hard copy records where the hard copy records are retained to meet recordkeeping requirements: Destroy when the agency determines that the electronic records are superseded, obsolete, or no longer needed for administrative, legal, audit, or other operational purposes.

Sensitive image files

AFRIMS table 44–03 does not specifically discuss sensitive (medical/legal) radiologic files; however, any radiologic file that is connected to pending litigation is indefinitely maintained until the litigation (lawsuit) is settled. Unfortunately in some cases it may take years for some litigation cases to come to judgment. Until then any and all radiology files labeled “sensitive” will forego following the normal disposition schedules.

Table interpretation and examples

Once you've located the radiology records disposition schedule on AFRIMS, you might agree it is fairly easy to locate the desired information. For example suppose you are unsure of the proper disposition of radiographs that cannot be identified with a patient. By reading down the left-hand column labeled "rule number", you find rule 20, "Unidentified Exposed X-ray Film." When accessing rule 20 on the website, you would notice this rule refers to X-rays that cannot be identified with those to whom they pertain (as referenced in "Column C which are"). Column D disposition states the disposition instructions and, in this example, it directs that these films are to be destroyed when encountered.

Rule 10 warrants discussion. It basically says that X-rays made in connection with diagnosis and treatment of patients at medical facilities should be destroyed after five years. In practice X-ray files are only destroyed after the file has been *inactive* for five years. This means if a patient returns for X-rays in a subsequent year, the patient's film file folder is brought forward from its original file year into the new file year. Only files that have been inactive for five full years are destroyed. To further explain, the earliest date a radiograph taken on 15 August 2011 should be destroyed is 1 January 2017 because the 2011 files have been inactive for five full years on this date; however, if the same patient returned for X-rays in 2013, then the folder should not be destroyed until 1 January 2019.

Digital film files

In the case of digital radiologic images, the above stated rules for maintenance and disposition do not apply because of the ease at which digital images are stored. Most USAF facilities' image maintenance policies state that digital images will be stored indefinitely. As of today, there is a DOD proposal in the works, though that would set the timeline for maintenance and disposition of digital radiographic images at 75 years.

Veterans Administration

The Veterans Administration (VA) assumes legal custody of all Armed Forces entrance and separation X-rays immediately upon their retirement to The National Personnel Records Center (NPRC). These records are destroyed after 65 years in accordance with both Federal Personal Property Management regulations and concurrence of the VA on each disposal action. Army Air Force X-rays dated prior to 1960 and Air Force X-rays dated prior to 1964 are destroyed after 65 years or when no longer needed in the reconstruction of military service records, whichever is later. The medical facility that forwards the medical health records to NPRC will remove the mammography image files and retain them until scheduled for destruction.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

010. Film filing, loaning, and transfer procedures

1. What is the name of the filing system used to organize film envelopes according to the sponsor's SSN?

2. Why are film file envelopes color coded?

3. Name the four parts of a SSN in the terminal–digit filing system.

4. What is the primary number in this SSN: 900-45-6789? What is the first part-tertiary number?

5. Using the terminal–digit filing system, place the SSNs in ascending order from first to fourth.

   ____ 923–14–5678.
   ____ 906–94–5466.
   ____ 936–57–5678.
   ____ 925–09–5566.

6. Match the authorized DEERS prefix code in column B with the appropriate patient designation in column A. Items in column B may only be used once.

Column A	*Column B*
____ (1) Father-in-law of sponsor.	a. 02.
____ (2) Civilian emergency.	b. 20.
____ (3) First spouse/former spouse.	c. 31.
____ (4) Second dependent child of sponsor.	d. 40.
____ (5) Active duty and retired military personnel.	e. 55.
____ (6) Mother or step-mother of sponsor.	f. 98.

7. Explain the process of film digitizing.

011. Maintenance of radiologic film files

1. What website is a one-stop shop for information pertaining to the maintenance of all types of Air Force records?

2. What series and table on the website provides guidance for maintenance of medical radiology records?

3. What rule governs the disposition of diagnostic X-ray film?

4. When are diagnostic X-ray films disposed of?

5. How long are mammography films maintained?

6. What is the earliest date a radiograph taken on 21 June 2011 may be destroyed?

3–2. Supply and Property Procedures

No matter how proficient you and other radiology personnel are, you cannot function effectively as a department without proper supplies and equipment. This materiel must be budgeted, ordered, and accounted for until it is either consumed or returned to medical logistics. This section will assist you with these procedures.

012. Property accountability and responsibility

Look around your duty section. You probably see variety of equipment and supplies. Who is responsible for these items? If you see someone abusing a piece of equipment, whose responsibility is it to report it? Management of public property includes the proper allocation, control, care, use, and safeguarding of public property under control of the Air Force. This process applies to each individual, if the property is signed for or issued to that individual for care or custody.

Custodial responsibility

Any individual who has acquired possession of government property has custodial responsibility for that property. The obligation to care for a particular property item is not limited to the person who has signed for the item. It includes anyone who uses, supervises the use of, or otherwise comes in contact with the item. For example the fact that you have not signed for the X-ray machines in the radiology department does not relieve you from the responsibility of properly caring for the units. You must take positive action to prevent the loss, damage, or destruction of the equipment. Of course, it is difficult to lose an X-ray machine, but many smaller items of equipment can easily be lost if appropriate accounting steps are not taken.

Property custodians

Property custodians are individuals who have been designated the authority to order, receive, and sign for medical supplies and equipment. These individuals do *not* assume ownership, but they do assume *full* responsibility for the proper care and use of the materiel for which they have signed. Within a medical facility, the medical group commander (MDG/CC) must designate such authority in writing. A copy is retained in the property custodian's file. Normally one property custodian is designated for each activity/section within the facility; however, if activities are small in scope and size, one custodian may be designated to cover several activities. If an activity is quite large in scope and size, an alternate property custodian maybe appointed to assist.

Supply representatives

Each property custodian has the authority to designate supply representatives to receive and sign for *only* medical and nonmedical supplies for his or her specific accounts. Such designation must be in writing and provided to the medical logistics section. The letter must include a sample of each representative's signature. The property custodian assumes full responsibility for all materiel signed for by his or her designated representatives.

Signature receipt is mandatory for certain categories of medical materiel. These categories are:

- Controlled medical items (e.g., narcotics, precious metals, etc.).
- All equipment items.
- Any other items specified by the major command (MAJCOM) or MTF commander.

Levels of responsibility

We have all seen the phrases "Property of the USAF" or "US government" stamped on the side of equipment. So if the item is the property of the "USAF or US government", who is responsible for the item? All members of the US government are responsible. Regardless of rank each person is charged with providing proper custody, care, and use, as well as safeguarding all government property. We

each have a responsibility to one another and to our fellow tax payers to make the best possible use of USAF property and resources.

There are four levels of property management responsibility: command, supervisory, custodial, and individual. It is possible for someone to carry more than one of these types of responsibility at the same time.

Level	Those Responsible	Roles and Responsibilities
Command	Commanders at all echelons are charged with ensuring that only qualified personnel are selected and assigned as accountable officers.	Commanders ensure: • There is space for proper storage of medical supplies and equipment. • Prescribed records are kept. • Supply discipline is understood and exercised.
Supervisory	Any person who exercises supervision over property received, in use, in transit, in storage, or undergoing modification or repair.	Supervisors are responsible for: • Selecting qualified personnel to perform the duties under their control and for properly training them. • Issuing supply procedures and instructions to ensure compliance with USAF and DOD directives governing public property. • Indoctrinating personnel in the principles of supply discipline.
Custodial	Any individual who has acquired possession of government property has custodial responsibility for it.	That individual is personally responsible for: • Property issued for official use, whether or not he or she has signed a receipt for it. • Storage, use, custody, or safeguarding of any property under his or her direct control. Custodians are required to comply with all directives and instructions relating to the handling and prompt, accurate documenting of property in their charge. They must promptly report to their immediate commander and, if appropriate, accountable officer, any losses or other irregularities relating to property in their charge. In addition, they start the paperwork to reconcile and correct property records. These responsibilities apply equally to subordinate personnel receiving property for their use.
Individual	Effectively managing property starts with, and must be applied by, everyone in the USAF, regardless of assignment. This applies to all civilian and military personnel, retired or active duty.	Each person is charged with proper custody, care, use, and protection of all government property under his or her control if they have signed a receipt. Property issued to individuals does not become private property by act of issuance or possession but remains public property. It must always be properly used, cared for, and safeguarded.

If you find government property appearing to be lost, stolen, or abandoned, you must assume custodial responsibility for it and protect or care for it until it can be returned to the proper authorities.

013. Responsibilities of the property custodian

Every radiology department has a *property custodian* who is responsible for requesting and accounting for all equipment within the department. The MTF commander designates and appoints

this person via an appointment letter. Property custodian duties typically are assigned as an additional duty for a competent and responsible individual. Regardless of who is appointed, acceptance of and relief from custodial responsibility is a very serious matter and should be dealt with in a professional manner. The first item to address when becoming the property custodian is the assumption of property.

Responsibility for Medical Equipment Management Office property

When you assume custodial responsibility, the base Medical Equipment Management Office (MEMO) provides you with a custodian receipt/location list (CR/LL) showing all property charged to the custodian's account. Before signing the listing, you and the current property custodian must perform a thorough inventory. You must visually account for all listed property. At the same time, obtain Medical Equipment Repair Center (MERC) verification that required maintenance/calibration has been completed. Any property that is in your duty area but not listed should be identified and coordinated with the MEMO. Only after the inventory has been performed and all corrective actions are documented should you sign for the property. Upon signing and dating the CR/LL, the new custodian assumes full responsibility for all in-use items in the quantities indicated and verifies the requirements for all equipment due-in (owed) on the listing. Remember, as custodian, the equipment becomes your administrative and financial responsibility, so do not take the word of the previous custodian—verify all items and the stock numbers. The originally signed CR/LL is returned to MEMO; as a record of equipment on hand, and the property custodian retains a signed copy. As items are issued to or turned in from the account, the property custodian retains the AF Form 601, the Equipment Action Request, and a copy of the custodial action list (CAL) indicating that the transaction was processed. When a new CR/LL is printed, the previous CALs may be discarded. The property custodian ensures, by spot checks and periodic inventory, that all property in his or her account is charged to the account properly and is physically on hand, or appropriate action has been taken to affect settlement for missing or damaged items. Before a property custodian is relieved from duty, transferred, separated from service, or absent from the account in excess of a 45-day period, the custodian must coordinate with MEMO to transfer the property or have it assigned to an authorized successor.

Performing or assisting in periodic inventories of medical materiel

The property custodian must ensure, by spot check and periodic inventory that all property is physically on hand or otherwise accounted for. Physical inventories of equipment must be performed at *least* once each year, but may be done more frequently, if necessary, to make sure safekeeping of the equipment. The property custodian or an inventory team composed of the property custodian and MEMO staff performs these inventories. Missing or damaged items are reported to the MEMO.

Equipment transfer and turn-in

Equipment may be relocated between property custodians when approved by the MEMO. To transfer equipment, the losing property custodian completes an AF Form 601, stating "Relocation of Property" in the justification block along with "transfer from/to" information. The following actions are taken:

1. Retain the original copy of the AF Form 601.
2. Forward four copies to base MEMO.
3. Obtain MEMO approval of the relocation.
4. Obtain the signature of the receiving property custodian on the AF Form 601 when the relocation is completed.
5. Forward the completed AF Form 601 to MEMO for processing.
6. The MEMO processes the document and sends a copy to both property custodians. The MEMO also provides a CAL containing the transfer documentation, which you file in your equipment folder. Destroy your original AF Form 601 upon receipt of the CAL.

As a property custodian, maintain a log of all AF Form 601s prepared, using AF Form 126, Custodian Request Log. The AF Form 126 serves as your control register for tracking AF Form 601s and for document control when completing AF Form 601, block 1.

Prepare an AF Form 601 and ensure that medical equipment is inspected by MERC before turn-in to the MEMO. MERC should enter the equipment condition code on the AF Form 601 and place an inspection tag on the equipment. The comment "no longer needed" in the justification block of the AF Form 601 is not enough; indicate why the item is no longer needed (e.g., mission change, reduction in patient load, unserviceable). Once the MEMO receives the AF Form 601, the equipment is scheduled for pickup. MEMO signs the AF Form 601 and gives a copy to you for your equipment folder. The signed AF Form 601 relieves you of all responsibility for the item.

Customer support listings

There are several medical logistic listings provided to property custodians to help manage their custodian accounts. There are listings that show the equipment you are responsible for maintaining, and there are listings that show how much money you spend on issues. Take the time to review the supply listings provided to you and ensure you understand the usefulness of each.

Equipment management listings

As you can imagine, one of the top priorities for a property custodian is effective management of supplies and equipment. Medical logistics provides several listings to aid the property custodian in the management of property.

Custodian receipt and location list

The purpose of the CR/LL is to indicate each specific item for which a custodian is responsible. The quantity and dollar value of assets on hand are shown in stock number sequence. The custodian's signature on the CR/LL indicates that possession of property is transferred. Before signing for an equipment account, MEMO provides you with a copy of this listing to help perform your initial equipment inventory. After the inventory is completed and any necessary adjustments have been completed, you are given a new listing for your signature. MEMO maintains a signed copy of this list in the MEMO property custodian file. The second copy is given to you for filing in your equipment folder.

Custodian action list

The custodian action list is an *interim* listing used to update the CR/LL. This list is produced each time Medical Logistics processes a change action affecting a custodian's account. The change may be an equipment issue, turn-in, transfer, or back order. The custodian action list is distributed, certified, and filed in the same manner as the CR/LL. You may destroy the custodian action list upon receipt of a new CR/LL incorporating the changes.

When you submit an AF Form 601 to the MEMO to record an equipment turn-in or transfer, normally you would receive a custodial action list within five workdays. If you do not, contact the MEMO. This is another reason it is important to maintain a file copy of your AF Forms 601 submitted to the MEMO. Your signed copy of AF Form 601 serves as proof if any questions of liability arise.

Three-year equipment budget requirements list

This list is produced twice a year during November and May and used for budgetary and financial plans for replacement equipment. Only equipment records containing a life expectancy code greater than four years and those having MEMO on-hand balances are considered on the report. Equipment items are reviewed and suggested for replacement based on MEMO criteria.

Each property custodian having equipment that meets the criteria for review is given a copy of Part I. Review the list with your officer-in-charge (OIC) and validate the requirements of your activity. If you determine a requirement is valid, indicate the replacement priority and prepare a supporting AF

Form 601 for each replacement item required. After completing the review, the annotated copy of Part I and AF Form 601 should be sent to the MEMO.

Customer support list uses

To make the property custodian's task easier, it is important to know the usage for different listings issued by medical logistics. Let us take a look at some of these reports.

Back-order report

The back-order report, or list, is produced at the end of each month for customers who have supplies or equipment due-in. The property custodian reviews the report for items requiring cancellation, follow-up status, quantity error, item error, etc. After reviewing the list and checking current on-hand supply levels, the property custodian returns an annotated copy to medical logistics by the *seventh calendar* day of the month if changes or cancellation of a due-in is required. Always keep a copy of the annotated copy turned back into medical logistics. Logistics uses your annotated list to a process cancellation request and any other appropriate changes. Be aware there is no guarantee that medical logistics will be able to cancel your due-out, but they will try.

Issue and turn-in summary report

The using activity issue/turn-in summary report is produced for each activity supported by Defense Medical Logistics Standard Support (DMLSS) that had issue action during the month. This listing contains all the issues, reversals, and turn-ins for your using activity.

The first portion of the report contains all issues and reversals of issues made during the month for each activity. The last page of each using activity contains a dollar value summary issued by refundable/reimbursable and nonrefundable/nonreimbursable for medical and nonmedical supplies and equipment. This information is helpful in managing your account funds.

The second portion of the list contains all turn-ins and reversals of turn-ins processed during the month for your activity. The last page of the list contains a dollar value summary for items turned in. Located to the right, the refundable/reimbursable line is the dollar amount you were granted credit on your turn-in. This money has been refunded to your account and can be used to make new purchases.

014. Report of survey

Property must be accounted for at all times. When an item is lost, destroyed, or damaged, a report of survey (ROS) is conducted to investigate what happened to the item. If negligence was involved, one or more persons may be held financially responsible.

Pecuniary liability

Pecuniary liability means an individual may have a statutory obligation to reimburse the government financially for loss, damage, or destruction of government property caused by his or her negligence, willful misconduct, or deliberate unauthorized use. Pecuniary liability may be the responsibility of one person or of several people involved in a given case.

ROS process

If the property is lost, destroyed, or damaged by means other than fair wear and tear, obtaining relief from property responsibility can be costly to the person charged with the custodial responsibility. This process usually begins with a ROS, which is an in-depth investigation performed by a designated survey officer. The ROS is documented on a DD Form 200, Financial Liability Investigation of Property Loss. The four general purposes of an ROS are:

1. Research and investigate the cause of loss, damage, or destruction of property and determine if it was attributable to an individual's negligence or abuse.

2. Assess monetary liability against individuals who have lost, damaged, or destroyed government property, or relieve them from liability if there is no evidence of negligence, willful misconduct, or deliberate unauthorized use of the property.
3. Provide documentation that can be used to support the adjustment of accountable records.
4. Provide commanders with case histories that will enable them to take corrective action to prevent recurrence of the incident.

Relief from property responsibility

You may be relieved of responsibility for a piece of property in a number of ways. For example you may turn the property in to medical materiel section as excess, or you may transfer it to another person; however, if the property becomes destroyed, damaged, or lost, the procedure is not quite so simple. If you admit pecuniary liability, the least troublesome way to settle a monetary obligation is to pay the debt with cash. The procedure is simple—DD Form 1131, Cash Collection Voucher, is completed, and you pay the government in cash for the property. This collection method can be used *only* if the amount involved is *less* than $500.

If you admit pecuniary liability but do not have the money to pay in cash, DD Form 362, Statement of Charges/Cash Collection Voucher, is used. The form simply authorizes the government to deduct the amount from your paycheck. DD Form 362 is also only used if the amount involved is less than $500.

When an individual does not admit pecuniary liability, is unwilling to pay, or the amount is $500 or more, a ROS *must* be conducted and documented on a DD Form 200, Financial Liability Investigation of Property Loss in accordance with AFMAN 23–220, *Report of Survey for Air Force Property*. Two people conduct the report of survey—the *appointing authority* and the *investigating official*. The appointing authority is a commander or other officer having jurisdiction over the person who has custodial responsibility for the property in question. The appointing authority appoints an investigating official whose duty it is to make a detailed and impartial investigation (survey) of the circumstances connected with the loss, damage, or destruction of property described on DD Form 200. The investigating official will be an officer, noncommissioned officer (E-7 or above), or civilian employee in a grade above general schedule seven (GS-7) or other commensurate civilian supervisory grades. If feasible the investigator will be senior in rank to the person(s) being investigated and be from a unit different from the one involved in the ROS. The investigator must be a disinterested, impartial individual who has no interest or involvement in the custodianship, care, accountability, or safekeeping of the property in question. The investigating official, based on the facts, makes findings and recommendations on the issue of liability of the person(s) involved.

Once the investigation is complete, the investigating official forwards the findings to the appointing authority. The appointing authority finalizes the report and takes necessary actions. As a result of the findings, the person responsible for the custody of the property in question may or may not be required to pay for it.

When final action is taken to hold an enlisted person pecuniary liable, the commander will advise the enlisted person of the:

- Right to appeal.
- Right to make direct remittance to the USAF office concerned within 30 days from the date of notification.
- USAF’s right to make involuntary deductions from the individual’s pay.
- Right to request remission of the indebtedness.

015. Categories of medical materiel

Equipment and supplies are categorized in relationship to how expensive the item is and how long you can expect to use the item. This section discusses materiel classifications and procurement.

Classification of materiel

Medical materiel is classified in two major categories: equipment and supplies. Medical equipment is further classified as expense or investment equipment, and supplies as consumable or durable. The following table explains the categories of medical materiel:

Category	Explanation	Examples
Medical investment equipment	Medical investment equipment denotes those items with a unit cost of $250,000 or more, a life expectancy of five years or longer, and maintains its identity during use.	A CT unit and an X-ray imaging system.
Medical expense equipment	An item classified as medical expense equipment is one with a unit cost of at least $3,300 but less than $250,000 with a life expectancy of at least five years.	A mobile X-ray unit and an automatic contrast injector.
Maintenance significant supply item	Less than $3,000 and requires some type of minor maintenance or inspection.	
Medical supply (consumable)	Medical items that lose their identity when used and cannot be reused for their original purpose.	Adhesive tape and injectable contrast media.
Medical supply (durable)	Medical supply items that maintain their identity when used and may be reused for their original purpose.	Hemostats, laboratory glassware, and stethoscopes.
Nonmedical materiel	These materiels are items that are nonmedical in nature and consist of two major categories: supplies and equipment. Nonmedical materiel used by USAF MTFs consists primarily of office, janitorial supplies, and equipment.	Office supplies, janitorial supplies, and computer printers.

Sources of procurement

The Air Force Medical Service (AFMS) purchases supplies and equipment from several different sources and through a variety of different methods.

Government sources

Items are stocked by the Defense Logistics Agency (DLA) or General Services Administration (GSA) and are available at materiel depots throughout the continental United States (CONUS). Materiel procured from these government sources is termed “stock listed” because each item is assigned a 13–digit national stock number (NSN). *Prime vendors* are another source that provides your MTF with many of the needed medical supplies. Contracted by DLA, they are civilian companies that *usually* deliver supplies the *next* duty day.

Local purchase sources

Medical Logistics can use another procurement source through the base contracting office (BCO), also known as local purchase (LP). It is used primarily to obtain items not stocked by DLA, GSA, or the prime vendor. Methods of local purchase include government purchase card (GPC), blanket purchase agreements (BPA), and requests submitted to the BCO for direct procurement from commercial vendors or manufacturers. The GPC is essentially a US government credit card whereby purchases are made and charged to the MTF and paid for with the unit’s operations and maintenance (O&M) funds. BPAs are contracts negotiated with a specific vendor to cover the recurring requirements for selected LP items.

Initially LP procedures can be a little more involved than normal depot ordering procedures, but don’t let that scare you. It’s not that complicated. There are unique management procedures, authorizations, and restrictions governing the procurement of LP items and nonpersonnel services that medical materiel personnel can easily explain to you. Because of the additional manpower and administrative

costs associated with LP, government sources (GSA, prime vendors, etc.) should be used as your primary sources of supply.

016. Requesting medical materiel and services

No matter what area of DI you work in, supplies, equipment, and services will be needed to fluently provide the utmost in patient care. Though you are reading this lesson early in your career, it is important for you to realize the importance of forecasting your needs and exercising good supply discipline.

Forecasting, budgeting, and requesting equipment and supplies

Certain supplies and equipment must be available for your section to complete its mission. Eventually you'll become involved in forecasting for equipment and supplies. There is nothing difficult about forecasting, but it does require a certain amount of planning.

From your own personal experience, you know that you must follow a budget to meet your expenses and get the most from your dollars. If you continually buy on whims without planning, your paycheck is soon gone and times may be tough until your next payday. The USAF is much the same; it must justify and submit a detailed budget plan before it can receive money. Also like your own paycheck, the money available goes only so far. Only the most essential items are approved for purchase.

Forecasting equipment requirements

If your section expects to make realistic budget requests, a long–range equipment program must be established and when forecasting future budget requirements, the following two situations must be considered: (1) Replacing existing equipment as it wears out through normal use, and (2) the procurement of new equipment.

The Equipment Replacement Report, obtained through DMLSS or MEMO, provides a list of equipment items needing replacement. This report can project requirement needs as far out as five years.

Forecasting for supplies

Unlike forecasting for your equipment budget, the resource manager and resource advisor will forecast your supply budget for you. Your supply needs for each fiscal year is based on what you were issued in the previous fiscal year. Of course, this does not mean that if you did not use an item last year you will not be able to order it this year.

Equipment and supply budgeting

Just as with forecasting, eventually you will become involved in budgeting for the supplies and equipment you use in your department. There is nothing difficult about budgeting either, although it does require a certain amount of careful planning as does forecasting.

Supply and equipment budgeting is done during the months of December or January. The resource management office (RMO) is *responsible* for preparing and submitting the entire medical facility's annual budget.

When the RMO requests a fund requirement for the coming year's supplies, calculate your section's need by reviewing the last fiscal year supply records, then comparing that to what was spent during the first quarter of the current year. This calculation is a simple matter since your monthly issue list shows a total dollar amount on the last page of each list. From this information you should be able to predict approximately how much you will need, based on previous expenditures. Also consider any upcoming changes in the workload and type of operative changes that might affect your requirements. Keep in mind other factors that may affect your workload, such as an increase or decrease in the base population.

The equipment budget is based on new and replacement equipment needs. The Equipment Replacement Report and MEMO approved/unfunded files are the basis for budget inputs. In addition, consider equipment authorizations in the applicable tables of allowance or equipment authorization lists. While projecting future equipment needs, keep in mind that the MTF commander is the final approval authority for all equipment requests.

Supply authorizations

Although requesting supplies from medical materiel may seem to be a very simple procedure, there is more to it than meets the eye. From time to time, you may have to turn these items back into medical logistics. This action could be the result of a suspension notice, reduction or change in workload, or poor management.

Each using activity in the MTF is authorized a *maximum* of a two-week level of consumable supplies and enough durable supplies to support operations until replacement items can be obtained from medical materiel. The actual level of stock is based on average usage and resupply frequency of recurring demand consumable supplies. This level varies with the type of commodity, user, and location of the supply account. Medical logistics should issue supplies to customers frequently to reduce levels of consumable supplies maintained in the using activities. This issuing frequency (daily, weekly, twice a week, etc.) is primarily determined by your consumption frequency. Attention is also given to other factors, including inventory reduction, time, and effort in making the issues, customer's available storage space, level of customer involvement in receiving the supplies, and demand rate.

Routine issue requests

There are two primary methods used by medical logistics to support customers' routine supply requests—forward logistics and customer area inventory management (CAIM). Here is how they work.

Forward logistics

The overall goal of forward logistics is to develop a proactive logistics function that is responsive to customer needs. Under this system you designate a primary supply storage area for automatic resupply. Forward logistic office-supported customers do not submit shopping guides for routine, recurring, fast-moving medical supplies. Medical Logistics *automatically* inventories, orders, balances, and delivers routine supply requirements to forward logistic office customers by a predetermined delivery schedule. Once the forward logistic office supplies are delivered to your supply point, it is your responsibility to ensure security and to monitor consumption of the supplies.

CAIM

CAIM seeks to provide a complete medical logistics function to all MTF customers. CAIM is not a top-down, structured program. Base-level logistics activities have considerable latitude to work with its customers to develop a program that best suits local needs. The main objectives of CAIM are:

- Improve customer service.
- Reduce O&M inventories.
- Reduce clinical personnel involvement in logistics functions.
- Reduce inventory required to support customers.
- Improve relations and trust in the logistics system.

CAIM enables the customer to identify materiel required for patient care and clinical support by providing automated support for requesting materiel, physical inventory, ordering, storage, receipt, and tracking of patient care related materiel up to the point of use.

Nonroutine issues

As-required or one-time requests for durable or consumable supply items are considered a nonrecurring requirement. These items are coordinated with medical logistics on an item-by-item basis. Normally, such items are not stocked by the medical materiel account. This category includes those items requested on a one-time basis with no foreseeable demand for one year. To request nonrecurring issues, complete a "New Item Request" using the DMLSS CAIM module.

Other types of issues

In a perfect world, all the supplies you might ever need would be readily available on a shelf in medical logistics; however, this is not the case! Medical logistics uses the following types of issues.

Emergency issue

This method is used to satisfy your urgent, unexpected needs in between regularly scheduled supply requests. To request emergency issue for an item, notify the customer service section of logistics; they will process your request and ensure the item is ordered or issued immediately.

Pre-issue

Pre-issues are items physically issued to the using activity prior to processing the issue transaction. It is like buying on credit or delayed payment. This method is only used when issue transactions cannot be processed through the DMLSS system (e.g., when the computer is down).

Back orders and back-order release issues

Back orders are established when there is *no* stock on hand or there is *not* enough stock to fill the total order. This item appears on your using activity issue list in the section titled "Back Order Action." When Logistics receives and processes the item, the computer generates a back-order release issue.

Turn-in and credit policies

From time to time, you will need to turn in supplies and equipment. The materiel may be turned in because of reduced workload, overstocking, or change in procedures or the mission of your section. Do not wait until just before an inspection to start looking at your excess supplies and equipment.

Acceptable turn-in items

Turn in unserviceable and suspended items to Medical Supply when identified as "other than serviceable." Turn in serviceable items when they no longer fit your requirements. Requests for replacement for the unserviceable items are a separate transaction but should be coordinated closely to ensure timely issue.

Turn-in procedures

It is the *user's* responsibility to turn in applicable materiel to the supply section. Normally, you deliver small supply items to the Medical Materiel warehouse for turn-in; for larger bulky items, coordinate the turn-in with the Logistics warehouse personnel. Medical logistics inspects the materiel for acceptability. Inform them of any factors that would help determine the condition of the item and why you're turning it in. The using activity must prepare a turn-in document, normally the DD Form 1348–6. Enter the reason for the turn-in in the "Remarks" block. The warehouse clerk receiving the turn-in provides you a signed copy of the turn-in document. If you have any questions concerning credit, discuss it with the logistics office, not the warehouse. Maintain your signed copy of the turn-in request until you receive a copy of the DMLSS generated issue/turn-in listing.

Credit may be allowed for turn-in of unserviceable items when there is a known credit to be received from a vendor or if the item will be reissued to another using activity within 30 days.

Principles of supply discipline

Supply discipline is *required* to conserve and protect Air Force supplies and equipment for operational requirements; it must be repeatedly impressed on all military and civilian personnel of the

Air Force, regardless of their specific career field or duty assignment. Supply discipline is important because the mission of the Air Force makes it imperative that equipment and supplies are operational and maintained in the best possible condition, in constant readiness, and in the absolute minimum quantity necessary to perform the assigned mission. This is done only through diligent application of the following principles of supply discipline:

- Maximum economical use of available equipment and supplies for their intended purpose.
- Effective safeguarding and preservation of public property.
- Adherence to procedures contained in established regulations and directives governing requisition, storage, issue, turn-in of property, and the control of sensitive and classified items.
- Continuous screening of stocks and prompt reporting, redistribution, and disposal of excesses.
- Scrupulous avoidance of issue request.

Ordering equipment

The office that manages the medical facility's equipment is the MEMO section of logistics. When requesting *new* equipment or when any *change* is required in equipment assets under your control, an AF Form 601, Equipment Action Request, is prepared. It's very important that you realize the approval process for investment equipment can take several months, and it can take several more months to get the funding from your MAJCOM.

When you wish to replace an old piece of equipment or buy a new piece that you do not currently have, submit a request form using The Integrated Global Equipment Request System (TIGERS) when the requirement is identified. Do not wait until the budget cycle; authorized/unfunded requests drive your budget—don't let your budget drive your equipment requirements. A description of the change required with a complete justification must be included.

In the justification, you should include the following:

- A description of where this item will be used and its function.
- What the current and projected workload is.
- Who is or will be qualified to use the equipment.
- How equipment will be maintained—by contract or MERC.
- The savings or benefits.

These only represent a few of the areas that should be addressed. Consult the logistics personnel in your facility for local procedures.

Requests for local purchase equipment should have a copy of the catalog page or descriptive brochure attached to the TIGERS request. Many times when you are trying to obtain a piece of specialized equipment, there will be only one manufacturer. When this is the case, submit a letter justifying sole source procurement. You must realize, even if right now there is only one source, within months several competitors may have a similar product for sale. This documentation is required by base contracting to avoid the appearance of favoritism, because other companies will not be given the opportunity to bid for the contract. The sole source justification is separate from the justification on the TIGERS request, and while it has no particular format, it must include:

- Complete nomenclature and descriptive data, manufacturer, and local distributor, if any.
- An explanation of the exclusive features of the desired item or services and why these features are needed.
- An explanation that there are no known substitutes.

- Why it is not practical to consider other sources for award.
- The extent of your research of possible sources in making the sole source determination.
- What the impact would be without this particular item or service.
- A statement pertaining to its dependability, safety, ease of use or operation, etc.

The completed TIGERS form is submitted to the MEMO for further action. If the item has a cost of less than $100,000, the final approval authority is the MTF commander. The MTF commander and higher headquarters *must* approve the request if the cost is above $100,000 but less than $400,000. It's not satisfactory just to write a good justification for your item. Attend the medical equipment review authorization activity (ERAA) meeting to justify and answer any questions concerning why your item must be approved. Once your 601 is approved, no further action can be taken until it is funded.

As with all things, your hospital places your approved equipment on a priority list with all other approved equipment for the hospital. Just where your requested item is placed on the priority list will be largely dependent on the justification and your involvement in the process. The ERAA board establishes purchasing *priorities*. So be ready to fight for the funds to buy your equipment, and don't be afraid to enlist the help of the senior person in your section. Remember just as your local ERAA makes a priority so will higher headquarters. Your request will compete with all of the other 601s submitted from other bases within your command.

Maintenance of equipment and facilities

Still under the area of medical logistics, you have *maintenance* of the equipment and the MTF. This section is *facility operations*. The individual in charge of this function has the title Chief, Facility Operations. The office of facility operations is *responsible* for housekeeping and the maintenance of equipment and facilities.

If you are requesting repairs, a work order must be submitted through DMLSS, which reports the malfunction to the facility operations personnel. Facility operations will, in turn, report the problem to the proper maintenance area. The procedure for submitting work orders may differ from base to base. Be sure you understand the procedures for your hospital. Work with all maintenance personnel by providing information on repairs to the facilities as well as equipment.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

012. Property accountability and responsibility

1. What is custodial responsibility?

2. What is a property custodian?

3. Who designates an individual to be a property custodian?

4. Match the level of property management responsibility in column B with the appropriate description in column A. Items in column B may be used more than once.

Column A	*Column B*
____ (1) Responsible for property that is undergoing repair.	a. Command responsibility.
____ (2) Responsible for property that has been issued to the individual.	b. Supervisory responsibility.
____ (3) Responsible for training personnel about supply discipline.	c. Custodial responsibility.
____ (4) Responsible for ensuring that there is space for proper storage of supplies and equipment.	d. Individual responsibility.
____ (5) Applies to everyone in the Air Force.	

013. Responsibilities of the property custodian

1. What listing does the MEMO provide the newly appointed property custodian when custodial responsibility is to be assumed?

2. When assuming custodial responsibility, when should you sign the CR/LL?

3. How do property custodians ensure that property in their account is properly charged to the account?

4. Under what circumstances will the MEMO take action to transfer a custodian’s property or have it assigned to an authorized successor?

5. At a *minimum*, how often is a physical inventory of equipment performed?

6. What form is completed to when equipment is transferred to another property account or turned-in to MEMO?

7. What is the purpose of the custodian receipt/location list (CR/LL)?

8. What does the custodian’s signature on the list indicate?

9. When is the custodian action list produced?

10. How often is a 3-year equipment budget requirement list produced?

11. For what is the 3-year equipment budget requirement list used?

12. What report contains *all* of the supplies or equipment owed a customer?

014. Report of survey

1. What is pecuniary liability?

2. What is the *least* troublesome way to settle a monetary obligation if you admit pecuniary liability for a gridded cassette that costs $400?

3. When must a DD Form 200, Financial Liability Investigation of Property Loss, be prepared?

4. What two individuals conduct the report of survey?

5. When final action is taken to hold an enlisted person pecuniary liable, what does the commander advise the enlisted member?

015. Categories of medical materiel

1. Match the materiel category in column B with the appropriate description in column A. Items in column B may be used more than once.

Column A	*Column B*
____ (1) Less than $3,000 in value and requires some type of maintenance or inspection.	a. Medical investment equipment.
____ (2) Loses its identity when used.	b. Medical expense equipment.
____ (3) A $100,000 mobile x-ray unit.	c. Maintenance significant supply item.
____ (4) A box of injectable contrast media.	d. Consumable medical supplies.
____ (5) Office and janitorial supplies.	e. Durable medical supplies.
____ (6) A $300,000 X-ray imaging system.	f. Nonmedical materiel.
____ (7) Hemostats.	
____ (8) A $750,000 CT unit.	

2. What procurement sources are civilian companies contracted by the DLA and usually deliver supplies within 24 hours?

3. What is *local purchase*, and when is it used?

4. What is a government purchase card (GPC)?

016. Requesting medical materiel and services

1. What two situations must be considered when forecasting future budget requirements with a long–range equipment program?

2. When RMO requests a fund requirement for the coming year's supplies, how do you calculate what money will be needed for your section's supplies?

3. What is the *maximum* authorized level of consumable supplies you should have in your work center?

4. Medical Logistics uses what two methods to support routine supply requests?

5. What is the overall goal of forward logistics?

6. What organization is responsible for inventorying, balancing, and delivering routine supply requirements to forward logistic office customers?

7. What type of issue method is used to satisfy an urgent, unexpected need in between regularly scheduled supply requests?

8. When is a back order established?

9. When may credit be allowed for turn-in of unserviceable items to Medical Logistics?

10. Why is supply discipline required?

11. Why is supply discipline important to the mission of the Air Force?

12. When you wish to replace an old piece of equipment or buy a new piece that you do not currently have, what system is used to submit a request form?

13. Who is the final approval authority for an item with a cost of $100,000? How about when the cost is greater than $100,000 but less than $400,000?

14. Still under medical logistics, what is the office of facility operations responsible for?

Answers to Self-Test Questions

010

1. The terminal–digit filing system.
2. To make it easy to spot misfiled folders within the shelving units.
3. (1) Primary number, (2) secondary number, (3) first part–tertiary number, and (4) second part–tertiary number.
4. 89; 45.
5. (1) 3.
   (2) 1.
   (3) 4.
   (4) 2.
6. (1) e
   (2) f.
   (3) c.
   (4) a.
   (5) b.
   (6) d.
7. It is the process by which hardcopy X-ray films are electronically scanned and the images are made into an electronic format to be stored on a PACS hard drive.

011

1. The AF Records Information Management System (AFRIMS).
2. Series 44 table 03 (or 44–03).
3. Rule 10.00.
4. Destroy five years after the end of the calendar year in which last film was taken.
5. 10 years after the end of the calendar year of the last film.
6. 1 January 2017.

012

1. The responsibility an individual has who has acquired possession of government property to keep it safe and ensure it is used properly.
2. Someone who has been designated the authority to order, receive, and sign for medical supplies and equipment.
3. The MDG/CC.
4. (1) b.
   (2) c.
   (3) b.
   (4) a.
   (5) d.

013

1. Custodian receipt/locator listing (CR/LL).
2. Only after the inventory has been performed and all corrective actions are documented.
3. By spot checking and making periodic inventories.
4. Before a property custodian is relieved from duty, transferred, separated from service, or absent from the account in excess of a 45-day period.
5. At least once each year.
6. AF form 601.
7. To indicate each specific item for which the custodian is responsible.
8. Indicates that possession of property is transferred.
9. Each time Medical Logistics processes a change action affecting a custodian's account.
10. Twice a year during November and May.
11. It is used for budgetary and financial plans for replacement equipment.
12. The back-order report.

014

1. It means that an individual may have to financially reimburse the government for loss, damage, or destruction of government property caused by his or her negligence, willful misconduct, or deliberate unauthorized use.
2. Pay the debt with cash.
3. When an individual does not admit pecuniary liability, is unwilling to pay, or when the amount is $500 or more.
4. The appointing authority and the investigating official.
5. The right to appeal, the right to make direct remittance to the USAF office concerned within 30 days from the date of notification, the Air Force's right to make involuntary deductions from the individual's pay, and the right to request remission of the indebtedness.

015

1. (1) c.
   (2) d.
   (3) b.
   (4) d.
   (5) f.
   (6) a.
   (7) e.
   (8) a.
2. Prime vendors.

3. Procurement by Medical Logistics through the base contracting office. It is used to procure items not stocked by the DLA, GSA, or prime vendors.
4. It is essentially a US government credit card whereby purchases are made and charged to the MTF and paid for with the unit's O&M funds.

016

1. (1) Replacing existing equipment as it wears out through normal use, and (2) the procurement of new equipment.
2. Calculate your section's need by reviewing the last fiscal year supply records and then compare that to what was spent during the first quarter of the current year.
3. A two-week level.
4. Forward logistics and customer area inventory management (CAIM).
5. Develop a proactive logistics function that is responsive to customer needs.
6. Medical Logistics.
7. Emergency issue.
8. When there is no stock on hand or there is not enough to fill the total order.
9. When there is a known credit to be received from a vendor or if the item will be reissued to another using activity within 30 days.
10. To conserve and protect AF supplies and equipment for operational requirements.
11. Because it is imperative that equipment and supplies are operational and maintained in the best possible condition, in constant readiness, and in the absolute minimum quantity necessary to perform the assigned mission.
12. TIGERS.
13. The MTF commander; approved by the MTF commander and higher headquarters.
14. For housekeeping and the maintenance of equipment and facilities.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

30. (010) Using the terminal-digit filing system for organizing radiographic film envelopes, determine, which group of social security numbers are correctly in order from 0 to 9.
    a. 901–31–6066, 936–56–5666, 945–10–5566, 906–94–5466.
    b. 942–10–5415, 983–51–8016, 932–25–8016, 912–49–3220.
    c. 912–56–0842, 945–34–1448, 934–38–1448, 976–38–1448.
    d. 945–10–5537, 946–23–5637, 936–23–5637, 906–94–5457.

31. (010) A prefix code of "40" in front of the sponsor's SSAN indicates that the patient is what relationship to the sponsor?
    a. Mother.
    b. Father.
    c. Mother-in-law.
    d. Father-in-law.

32. (011) According the AF Records Information Management System (AFRIMS) webpage, table 44–03, Radiology Records, rule 14.00 maintenance and disposition schedule, at what point should mammography and breast ultrasound films be disposed of under normal circumstances?
    a. 5 years after the end of the calendar year of the last film.
    b. 10 years after the end of the calendar year of the last film.
    c. 75 years after the film was created.
    d. Indefinitely.

33. (011) Under normal circumstances, what is the earliest date a chest X-ray taken on 15 August 2011 should be destroyed?
    a. 1 January 2016.
    b. 15 August 2016.
    c. 1 January 2017.
    d. 31 December 2017.

34. (012) The responsibility an individual has when they have acquired possession of government property is
    a. supervisory responsibility.
    b. individual responsibility.
    c. custodial responsibility.
    d. pecuniary liability.

35. (012) The following individuals ensure the proper care and safekeeping of an X-ray machine *within* the radiology department *except*
    a. the superintendent/NCOIC.
    b. the individual technologist.
    c. the property custodian.
    d. the medical equipment repair technician.

36. (013) At a *minimum*, how often must property custodians conduct a physical inventory of their property accounts?
    a. Yearly.
    b. Quarterly.
    c. Each time equipment is issued or turned in.
    d. Only when the account is transferred to a new custodian.

37. (013) Which document indicates each specific item for which a custodian is responsible?
    a. Activity issue/turn-in summary.
    b. Custody receipt and location list.
    c. Custodian actions list.
    d. Back order report.

38. (013) Which document is used as an interim listing to update the custody receipt locator list?
    a. AF Form 601, Equipment Action Request.
    b. Activity issue/turn-in summary.
    c. Custodial actions list.
    d. Back order report.

39. (013) When changes or a cancellation of a due-in is required, the property custodian *must* return the annotated back order list to the medical logistics flight by the
    a. seventh calendar day of the month.
    b. fifth calendar day of the month.
    c. seventh duty day of the month.
    d. fifth duty day of the month.

40. (014) The statutory obligation of an individual to reimburse the government for loss, damage, or destruction of government property arising from his or her negligence is the definition of
    a. pecuniary liability.
    b. monetary liability.
    c. financial liability.
    d. fiscal liability.

41. (014) A report of survey for Air Force property must be conducted when
    a. property damage less than $500.
    b. there is no evidence of gross negligence.
    c. damaged property causes personal injury.
    d. the individual is unwilling to pay for damages.

42. (015) Which are additional classifications of medical equipment?
    a. Medical or nonmedical.
    b. Consumable or durable.
    c. Expense or investment.
    d. Supplies or equipment.

43. (015) Which end item of medical equipment has a unit cost of $250,000 or more, a life expectancy of at least 5 years, and maintains its identity during use?
    a. Maintenance significant supply item.
    b. Medical investment equipment.
    c. Medical expense equipment.
    d. A medical supply item.

44. (015) A medical supply item with a unit cost of *less* than $3,000 that requires upkeep is classified as
    a. a maintenance significant supply item.
    b. medical investment equipment.
    c. medical expense equipment.
    d. a medical supply item.

45. (015) Which of the following examples is a durable medical supply item?
    a. Silk tape.
    b. Hemostats.
    c. Contrast media.
    d. Impervious isolation gowns.

46. (015) Which statement *best* defines prime vendors?
    a. Civilian companies contracted by Defense Logistics Agency (DLA) that usually deliver supplies within next duty day.
    b. Civilian companies that accept the International Merchant Purchase Authorization Card (IMPAC).
    c. Civilian companies with which the government has a blanket purchase agreement.
    d. Civilian companies that use the 13-digit national stock number (NSN).

47. (016) The *maximum* stock level of consumable and durable supplies that may be kept on hand is the amount that is normally used to support operations for how many weeks?
    a. One.
    b. Two.
    c. Three.
    d. Four.

48. (016) For fast moving routine medical supply items, Medical Logistics uses what system to *automatically* inventory, order, balance, and deliver stock requirements.
    a. Pre-issue.
    b. Forward logistics.
    c. Customer area inventory management (CAIM).
    d. Defense Medical Logistics Standard Support (DMLSS).

49. (016) What form is used to request new equipment?
    a. AF Form 601.
    b. AF Form 988.
    c. DD Form 1131.
    d. DD Form 1348–6.

50. (016) Who is the final approval authority when purchasing a $300,000 digital X-ray unit?
    a. Air Force Medical Operations Agency (AFMOA).
    b. Medical treatment facility commander and AFMOA.
    c. Medical material commander and higher headquarters.
    d. Medical treatment facility commander and higher headquarters.

51. (016) What entity establishes priorities for purchasing new equipment for the facility?
    a. Medical group commander.
    b. Resource management office (RMO).
    c. Equipment Review Authorization Activity (ERAA).
    d. Medical equipment management office (MEMO).

52. (016) Which agency is responsible for the maintenance of the medical treatment facility (MTF)?
    a. Facility Operations.
    b. Resource Management.
    c. Biomedical Equipment Repair.
    d. Medical Equipment Repair Center.

Student Notes

Unit 4. Quality Management

THE USE OF RADIATION for diagnostic medical purposes has benefited mankind since the early 1900s. The benefits range from identifying small fractures to discovering if a patient has cancer or other deadly diseases; however, the use of radiation has a variety of variables that can lead to a low-quality image. If an image is produced that is not acceptable, the radiologist will not be able to accurately diagnose a condition or might possibly misdiagnose the patient's condition. Additionally images may need to be repeated if the quality is below the minimum standards. Repeating images causes more radiation dose exposure to patients. Quality management (QM) is ultimately a business application focusing on the customer. Customers are the patients and our goal should be to provide them with excellent patient care practices, ensure the images taken are of high quality, and ensure the radiologist interpretation matches the eventual patient condition. In this unit we will discuss how quality assurance (QA) and quality control (QC) programs help to make sure DI departments provide the best patient care while consistently producing high-quality images repeatedly.

4–1. Quality Assurance

QA programs include all the behind-the-scenes decisions, initiatives, and policies put in place to make the patient's experience in DI as smooth, complete, and comfortable as possible. QA exists to continuously improve and enhance how patient care is delivered through the collection and evaluation of various data points. Some of the areas monitored by a typical QA program are patient scheduling, wait times, review of operating instructions, staff competency through continued education, and repeat image analysis.

017. Quality assurance in diagnostic imaging

Since the standard of quality is always changing, QA deals with people and every aspect of the department affecting the quality of medical care. People are the main focus of a QA program. QA is a program assuring patients, insurance companies, and The Joint Commission (TJC) that patient care will be the highest quality.

Reasons for quality assurance programs

In the 1970s, TJC started to mandate QM programs within hospitals before they would accredit them. Although no law requires a hospital be accredited by TJC, it will not be reimbursed by insurance companies, be able to hold medical licenses, receive malpractice insurance, or host a residency program for physicians if not accredited by TJC. It is because of TJC that DI departments have an extensive QM program seeing that high-quality care will be received. TJC has set standards for hospitals requiring well-planned, process oriented, and career field–wide approaches for monitoring QM and the methods of improving deficiencies to provide patient care.

The many benefits patients receive from DI departments are only beneficial if the quality of the patient's total care experience is high. This experience includes everything from scheduling to levels of patient exposure to radiation, all to produce a quality image for a radiologist to interpret. Years ago the concept of As Low As Reasonably Achievable (ALARA) was coined as it was determined that due to the dangerous effects of excessive exposure to ionizing radiation, only the lowest amount of radiation necessary to produce a quality radiograph should be used. Unfortunately many factors can contribute to radiation overexposure, and this has caused entities like the American College of Radiology, the American Association of Physicists in Medicine, TJC, and the federal government to regulate further the use of diagnostic radiation.

X-rays must be completed with incredible quality, without repeats, for the radiologist to appropriately diagnose any medical condition that the patient may have. The *goal* of every DI department is that the radiologist's diagnosis is ultimately in agreement with the patient's disease. This concept is known as the *outcome analysis*. To make certain that healthcare organizations are fully committed to providing the highest quality care, TJC encourages organizations to adopt TJC's 10–step QA program that helps DI leaders achieve a QA program that gives timely imaging services and great patient care with the correct outcome analysis. One QA area of concern in every DI department is the amount of radiation the patient receives.

Patient dose concerns

With conventional film-screen radiography, it could be determined quite easily if the image and patient was under or overexposed to radiation based on how light or dark the radiographic film turned out; however, computed radiography (CR) and direct radiography (DR) systems create unique challenges in this area due to the way these systems use computer algorithms to convert data into shades of gray (density) on a monitor while at the same time allowing latitude for doctors and techs to make adjustments to the displayed image (darker or lighter).

When using CR and DR systems, the image acquisition can correct a gross overexposure, up to 500 percent, without negatively affecting the overall quality of an image. This correction happens because the analog-to-digital converter (ADC) assigns each pixel on the computer screen with a numerical value that correlates to the strength of the electronic signal read by the ADC. That numerical value relates to a specific shade of gray using complicated math equations. Postprocessing then allows the technologist to adjust contrast and density by changing the assigned numerical value; if the numerical value of each pixel is so high that it creates a dark image, the technologist can simply decrease the assigned numerical value to bring the image into a viewable density. This presents a difficult task for the QA program because the latitude that a CR or DR system gives enables radiographers to become careless with the amount of radiation used. A common thought process for unskilled technologists is "when in doubt, burn it out." Unfortunately that philosophy is the exact opposite of what the ALARA principle tries to achieve.

Luckily manufacturers have developed a method to aid QA technologists and physicists in measuring radiation used during the production of digital images. DR systems record the exact amount of kilo–voltage peak (kVp) and milliamperage and time (mAs) as data under the patient's information for each image taken. CR systems provide digital measurements identifying the amount of radiation received by the imaging plate. The basis is that a numerical value is assigned to show the *sensitivity* of a digital imaging system to the amount of radiation the imaging plate received. This sensitivity is shown differently by manufacturer; therefore, the three most commonly used systems are discussed.

Agfa-Gevaert

The Agfa-Gevaert (Agfa) system establishes a numerical baseline value of, as an example, 10 millirad (mR) and attaches it to a numerical value known as the log median exposure (LgM). If the department's baseline was 10 mR, the LgM would be zero. Since the system is based on the log median system, every time the mR is doubled in exposure dose, the LgM increases by 0.3. The system would then assign a range of acceptable LgM to exams taken in the table-bucky and a range

for tabletop exams. As an example when using an Agfa system and the baseline for an image is 10 mR at 0 LgM, an increase in LgM to 0.3 would mean that the exposure doubled to 20 mR. This would continue after each increase of 0.3, meaning a new LgM of 0.6 will show that the imaging plate received 40 mR. Since Agfa has varying speeds of CR imaging plates, like 200 and 400, it is pertinent to know that changing the plate speed will alter the LgM baseline and how it is measured. For this reason it is important that the LgM chart matches the speed class of the imaging plates you intend to use.

Fuji

Fuji systems measure the amount of amplification needed by the photomultiplier tube when processing the CR imaging plate. As the imaging plate is processed, a red laser scans across it and blue light is released, which is equivalent to the radiation absorbed during exposure. The photomultiplier tube receives this radiation and amplifies it to be read by the ADC. The amount of amplification is assigned a numerical value known as a sensitivity-number (S-number). The S-number is inversely related to exposure in mR, so a large S-number shows that the patient received a lower amount of radiation, while a small S-number shows an increased radiation dose to the patient. For example if an exposure of 1 mR has an S-number of 200, as the S-number decreases closer to zero, the mR increases. Instead of memorizing a rate at which the mR changes based off the S-number, most systems will have a chart displaying acceptable S-number values for nongrid and gridded exams (i.e., grid exams should have an S-number between 100 and 400 with 200 being optimal).

Kodak

Kodak's CR indicator system reads radiation that is absorbed in the imaging plate at a directly proportional rate and is termed the *exposure index*. As an example an exposure of 0.1 mR will have an exposure index of 1,000. When 1 mR is reached, the index will jump to 2,000. Furthermore, the index will jump to 3,000 when the dose reaches 10 mR. The majority of properly exposed images in Kodak systems have an index value between 1,800 and 2,000.

The software of digital imaging postprocessing systems adjusts for a wide latitude of exposure technique errors; however, as the under- or overexposure exceeds the limitations of the postprocessing software, detail and image quality diminish. Additionally with the increased sensitivity of digital IRs to scatter and background radiation, image fog is more of a concern on the finished image. To reduce scatter and the negative effects of fog on a nongridded image, you should limit the kVp setting to 80 or less.

Benefits of quality assurance

QA seeks to improve the care that a customer receives. In DI, we consistently strive to produce high-quality images while using the lowest amount of ionizing radiation possible (ALARA). To achieve this, QA programs should incorporate TJC's 10-step process to identify problems, monitor problems, and then resolve the problems with corrective measures. The critical aspect of QA is that the patient benefits whenever problems are identified and resolved. The most obvious benefits of a QA program *are* time saved, improved customer service, reduced patient dose, and increased image quality.

018. Factors affecting image quality

Producing a high-quality radiographic image for a radiologist to read and interpret should be the goal for every DI technologist. Various geometric factors like magnification and distortion as well as subject (patient) factors like part size and tissue composition influence how each image turns out. Though geometric factors will be discussed again later in this course, it is important to understand some basic concepts on how magnification, distortion, and focal-spot blur affect radiographic image quality.

Geometric factors affecting radiographic quality

In its most basic form, radiographs are created when a radiosensitive material (an IR) captures the radiation energy in the form of a latent image that can be viewed after some sort of processing. Once produced, X-ray photons travel in a straight line; they cannot be made to turn but can only be directed towards the area of interest. This is an important characteristic to keep in mind when attempting to control the negative effects of geometric factors.

To understand how the path the X-ray photons travel affects the finished radiograph, a simple comparison is that to a shadowgraph. For example if you hold your hand in front of a light source with the shadow projected on a wall, you have created an image or shadowgraph. Three different things will happen to the image when changing either the position of your hand or the light source. If you bring your hand farther away from the wall, your hand will get larger, and the sharpness of the shadowgraph is diminished. The opposite is then true if you move your hand closer to the wall; the sharpness of the shadowgraph improves. Additionally if you leave your hand at a certain distance from the wall and increase the distance of the light source from the wall, you will see an increase in the detail of your hand on the shadowgraph. In turn, moving the light closer to the wall without moving your hand will reduce the detail of your hand. These geometric conditions also affect the creation of a radiographic image and the quality seen on the finished image. Understanding them will enable you to reduce poor-quality exams and aid the radiologist in providing an accurate diagnosis. The three principal geometric factors that affect radiographic quality are magnification, distortion, and focal-spot blur.

Magnification

Referencing the shadowgraph exercise performed with your hand and a light source, we can now attach terminology that ties to radiology. The distance between your hand and the wall will be the object-to-image distance (OID), while the distance between the light source and the wall will be the source-to-image distance (SID). Additionally the wall is metaphorically the IR, while the light source is our X-ray tube.

Magnification is defined as the enlargement of a radiographic image in relationship to its true size.To improve image quality, you must reduce OID and increase SID to control the magnification of the body part. Doing so will make sure the body part is projected on a radiograph as close to its actual size as possible.

Distortion

A body part is considered distorted when it is not projected on the radiograph in its true shape and size. There are two types of distortion: size distortion (magnification) and shape distortion. Referring to our current shadowgraph example, leave the flashlight at a perpendicular angle to the wall, but angle your hand to the projection of the light; you will notice that your hand appears shorter (foreshortened) than its true length. Additionally if you leave your hand parallel to the wall and angle the flashlight (similar to the sun casting your shadow across the ground), your hand will appear much longer than normal (elongated). Like magnification you can keep distortion to a minimum by keeping the X-ray source perpendicular to the body part and IR. On occasion though images are taken with purposeful distortion like in the case of an anterior-posterior (AP) axial (Towne) projection of the skull.

Focal-spot blur

The third factor in radiographic quality is defined by the focal-spot size. The angle of the focal spot, because of its rectangular shape, creates a divergent (spreading out) effect on the X-ray beam. Using as small a focal spot as possible reduces the amount of beam divergence that is generated; this, in turn, improves image quality and detail. Divergence causes blurring of information around the edges of a body part known as *penumbra*.

There is much more to be said about magnification, distortion, and focal-spot blur that will be covered later in this course; however, to limit the effects of each factor on the finished radiograph and improve radiographic quality, it is best to keep the anatomical part parallel to the IR, direct the central ray perpendicular to the IR, keep OID to a minimum, use the maximum amount of SID, and use the smallest possible focal-spot. Doing so will decrease penumbra (blur), thereby increasing the sharpness of structural lines on a finished radiographic image.

Subject factors

Subject (or patient) factors affecting image quality are primarily associated with characteristics such as part size, tissue composition, and shape of the anatomical part being imaged. Various body parts selectively absorbed of X-ray photons directly affect image contrast and density. When an X-ray beam is directed toward a body region, such as the chest, some parts of the region absorb more X-ray photons than others. For example the heart absorbs more photons than lung tissue. Consequently the portion of the IR beneath the lung tissue receives more photons and, when processed, appears darker than the portion of the image beneath the heart. As you can see, selective absorption results in different densities, or contrast, on a radiograph. The *factors* that affect selective absorption and subject matter contrast on a finished radiograph are part thickness, atomic number, tissue density, and the kVp setting.

019. Artifacts

Another aspect of image evaluation is identifying unwanted items on a radiograph, or an artifact. Artifacts can be caused by different means when comparing conventional film-screen radiography and digital systems like CR and DR. Understanding what these artifacts look like, what causes them, and how to fix them is very important to a QA program because artifacts cause repeated and increased radiation exposure to the patients. We begin with conventional film-screen artifacts.

Conventional film-screen artifacts

An *artifact* is defined as any unwanted optical density on the finished radiograph. The source of film artifacts can be seen within three primary categories: processing artifacts, storage and handling artifacts, and exposure artifacts. The primary sources of processing artifacts come from the transport system in an automatic processor, film-emulsion pickoff, gelatin buildup, pi lines, or chemical fog. Poor film-screen contact, improper film-screen match, or mistakes in patient preparation can cause exposure artifacts. Lastly storage artifacts stem from humidity, temperature, and static, while handling artifacts deal with the technologist's ability to gently handle the film and prevent kink marks.

Processing Artifacts	Exposure Artifacts	Handling & Storage Artifacts
Emulsion pickoff	Motion	Light fog
Gelatin buildup	Patient position	Radiation fog
Curtain effect	Wrong screen-film match	Static
Chemical fog	Poor screen contact	King marks
Guide shoe marks	Double exposure	Hypo-retention stain
Pi lines	Warped cassette	Scratches
Wet pressure sensitization	Improper grid position	
Dichroic stain		

Identifying the root cause of an artifact is a major step in understanding why the artifact appeared on your finished image. After the cause is identified, begin the process of fixing the issue whether it is dirty rollers in the automatic processor, a light leak in the darkroom, or providing handling and storage training for a colleague. Further discussion will take place later in this course regarding film-screen characteristics, storage of film, and automatic processors.

Digital radiography artifacts

Conventional film-screen and wet-processing systems are not the only systems that have to deal with artifacts. Unfortunately CR and DR systems are also prone to the occurrence of artifacts. Once again you must be attentive enough to recognize the artifact exists on an image and then be intelligent enough about the process/system to research why it is appearing to correct the issue.

Image plate defects

As the imaging plate ages, it becomes prone to cracks that appear as areas of lucency on the image. Other defects are scuff marks and scratches; all of these defects can misrepresent fractures or other conditions that can lead to a misdiagnosis. Image plates should be routinely inspected for issues and, if any are found, removed from use.

Foreign objects

Foreign objects, like dirt, dust, or hair, at some point always seem to find their way into a processing system. These artifacts appear as light lucency marks on your finished image because foreign objects act as a barrier and block the data underneath from being read by the processor. If foreign object artifacts are noted, have the processing unit serviced for cleaning.

Heat blur

If the imaging plate is exposed to intense heat, the phosphor layer may be permanently damaged. Heat damage causes a blurring effect and a decrease of density due to decreased data storage in the area affected. When this problem is identified, remove and replace the imaging plate so future occurrences of the artifact are prevented.

Image brightness errors

Image brightness errors are typically caused by the *wrong* histogram being selected when processing the latent image.When processing a digital image, you must select the proper histogram (a preprocessing imaging protocol) to tell the system how to interpret the pixel's stored energy. For example selecting a knee histogram preprocessing protocol for an adult chest image would cause the CR system to interpret the pixels incorrectly, causing the wrong image brightness (density and contrast) to be displayed. Another issue causing problems with how image brightness is displayed is nonparallel collimation. For CR histograms to correctly read the edges of the exposure field, the collimated borders should be parallel with the edges of the imaging plate.

Scanner malfunctions

Malfunctions occurring with the laser that scans the imaging plate within the CR reader can cause the laser to skip lines, misread pixels or not read them at all, and distort images. Memory problems, digitization issues, and circuit communication errors typically cause scanner malfunctions. Though the life expectancy is long for the internal components of a CR reader, it is possible for the laser or any of the other electronic parts to malfunction or stop functioning. In this case have the unit serviced for diagnosis and repair.

Printer errors

CR and DR systems utilize laser printers that, when requested, produces hard copy of images. If not properly calibrated and maintained, the printer can cause a number of image quality issues: incorrect density calibration, light leaks, transportation problems, and laser misalignment. These artifacts lead to shaded areas that produce darkness on the image.

Scatter radiation

Digital systems are *more* sensitive to scatter radiation than conventional radiography due to the phosphors containing lower K-shell values. As you have already learned in your technical and clinical training time, scatter radiation decreases image contrast, and with regards to digital systems, the

postprocessing software algorithms may not be able to appropriately correct and clean up the finished image.

Double exposure artifacts

Double exposure artifacts are often caused by the technologist's negligence. It occurs when an imaging plate is exposed and then mistakenly exposed again without being switched out for a new, clean IR. Paying attention to detail will prevent this form of double exposure. Another situation is when CR plates are found in an X-ray suite, leftover from a previous study. In this case make sure to have these leftover IRs thoroughly erased both using them on the next patient.

Phantom or ghost images

Sometimes during the processing of the imaging plate, not all of the latent image data is cleared from the imaging plate during the erasure phase of processing. Whether this is caused by imaging plate age or an excessive amount of radiation used, it causes a previous exposure to appear superimposed with the current exposure. If a double exposure is visualized, check if the imaging plate is thoroughly erased and repeat the exposure again.

020. Image quality control and evaluation

Image quality is determined by what we can see on the finished radiograph. As DI technologists we visually evaluate the level of density (amount of blackening), scale of contrast (shades of gray), if the body part looks the appropriate size (magnification/distortion), and if there is anything on the image that shouldn't be there (artifacts) to determine the quality of an image. It is inevitable that we will encounter occasional problems when trying to produce quality X-ray images because of all the factors, both controlled and uncontrolled, that go into creating a high-quality finished radiograph. Image quality control begins with the analytical process.

The analytical process

Image evaluation is performed every time you make an X-ray and process it, whether conventional or digital. This is the point where you find out whether or not your positioning efforts, technique selection, and patient instructions worked. When considering if your image is high-quality or not, you must consider a wide spectrum of factors to decide if your image should be repeated or not. This skill takes time, clinical experience, and requires seeing hundreds (or thousands) of poor and high quality images to understand what is good and what is not. By this point in your career as a DI technologist, you have surely evaluated image quality on all of your own images and many of your colleagues. You have learned how to visualize the correct positioning of various body parts, how to identify anatomy and pathology, and how to recognize what is a good density or contrast level for a particular exam. Image evaluation may very well be the most often performed task throughout your imaging career. The process of analyzing the finished radiographs might be difficult at first, but with information provided here and more experience in the field, you will no doubt become better at identifying the good versus not-so-good images you produce. When you analyze an image, you must review and compare it to similar views you have seen in the past. This is your book of knowledge that can be applied to determine whether or not your image is good.

Critiquing the image

After processing your image, all sorts of questions will likely go through your mind as you view your image on the computer monitor. There are nine basic questions to ask yourself when critiquing an image:

1. Is the correct name on the image?
2. Can you see the lead anatomical marker, and was the correct marker used?
3. Was the correct body part imaged? This is based off what was requested by the physician.

4. Is the body part positioned correctly? For example in the case of an AP knee, is the width of the femorotibial joint space equal on both sides?
5. Are all of the anatomical structures shown on the image as they should be? For example, are the costophrenic angles visualized or clipped off on a posterior-anterior (PA) chest image?
6. Is the body part represented as close to its true size and shape as possible?
7. Is the scale of contrast appropriate? Short for bony/orthopedic images and longer for soft-tissue (chest/abdominal) images.
8. If looking for specific pathology like a fracture or dislocation, do you see it?
9. Is there anything on the image that should not be there? For example a ghost image because the IR plate wasn't totally erased from the previous exam, a wedding ring when performing a PA hand, or other pathology indicating disease.

Whenever an artifact, error, or problem is identified in an image, you must begin digging deeper to fully capture if the image is acceptable, what caused the problem, and how to possibly correct or prevent the problem in the future. This thought process is critical to reducing repeat rates and improving the quality of patient care you provide.

Acceptable versus unacceptable images

When critiquing an image, you must evaluate it to determine if it is within the diagnostic limits your department uses to deem an image acceptable or not. It is unacceptable to "pass" an image to your radiologist that is clearly rotated or has anatomy clipped off. When you or your QA/QC tech approves the image as a quality radiograph, it means the radiologist will be able to use it to interpret what is going on for the patient. If the radiologist cannot use the image for interpretation, then a repeat image might be necessary. Most USAF facilities utilize a senior technologist as the QA/QC tech to review and "approve" all images before sending the images off to the radiologist. You should always critique your image first and then listen to the QA/QC tech for what they see. Did you see the same things?

Here are some reasons why an image may *need* to be repeated:

- Technique too much or not enough; check the S-number for proof of a proper exposure.
- Positioning errors; rotation, over or under-extension, incorrect angle of obliquity, etc.
- Wrong patient identification is on the image.
- No lead anatomical marker or the wrong one was used.
- Anatomy is superimposed, clipped, or missing.
- An artifact is in the anatomy of the image.

Make sure you follow your department policies regarding passing or repeating images. Some senior, seasoned technologists may have the liberty to decide when an image needs to be repeated without consulting the QA/QC tech; however, that typically only applies to a select few. Use the QA/QC technologist; evaluating images for quality is his or her job, and remember they are there to help you learn! Repeating an image or two may seem like *no big deal*; however, it is a big deal because repeat images mean more patient exposure to ionizing radiation and, as you should know, radiation dose is cumulative.

Determining the cause of the problem

When an image quality problem is identified, you must find the root cause, so the chances of the problem happening again are reduced. If the cause is a positioning error, that is on you to learn and understand what you did wrong to cause the error so you don't do it again. Some errors though have several causes requiring thorough analysis before truly understanding what went wrong. The majority

of image quality problems fit into one of *three* categories: technical factor problems, procedural problems, or equipment malfunction problems.

Technical problems

Problems associated with technical factors create an issue with visibility of optical density and subject contrast. If an image is too dark, it is easy to determine too much technique (kVp and mAs) was used. With digital radiography you might be able to adjust the image to look visually "acceptable", but again, what is the S-number for the exposure? Though current digital systems correct for many technique errors, if an S-number is out of the acceptable range approved by the manufacturer or your radiologist, then the quality of the image is not good enough and should be repeated. The reason for repeating an image because the S-number is out of range is because of an effect called *quantum mottling.* Quantum mottle is caused when there is a disturbance in the recorded detail of a radiographic image. Quantum mottle causes variations in optical density, which degrades image quality, causing the image to appear blurry or fuzzy. When the digital system/processor has to correct beyond what it is capable of, quantum mottling occurs to some degree on the finished radiograph.

As discussed previously geometric factors degrade image quality. The focal-spot size, SID, and OID can be manipulated to decrease magnification and distortion, while increasing image quality. Controlling geometric exposure factors will increase your ability to produce high-quality images and, in turn, reduce the radiation exposure your patients receive.

Procedural problems

Patient positioning and patient preparation for radiographic exams are procedural factors that can lead to problems, if not performed correctly. To prevent procedural problems, follow your department's standard operating procedures (SOP) to properly position the patient, correctly direct the central ray at the area of interest, and use the appropriate SID for performance of radiographic exams. Common errors falling under this area are tube-part–IR misalignment and body part positioning errors. Patient preparation involves, among many things, removing radiopaque objects from the anatomical part being imaged, clearly stated pre and postexposure instructions; and for gastrointestinal studies, ensuring the patient has a clean bowel tract. Paying attention to detail and exercising clear communication skills will correct patient preparation issues.

Equipment problems

As it will be discussed more later in this unit, equipment is the primary area of concern within a QC program. Monitoring the performance of the equipment you use, making sure that preventive maintenance is performed on schedule, and utilizing machines for their intended purpose all contribute to the production of quality images. If the X-ray imaging systems, processors, and display monitors are not properly cared for, artifacts can appear or, worse yet, system failures may happen. When critiquing your images and you find an unexplained artifact are on the image, this could mean a problem with the IR or processing unit. It is important to pay attention to the performance of your equipment, and when problems are encountered, notify your noncommissioned officer in charge (NCOIC) or a biomedical equipment repair technician (BMET) so the issue can get fixed.

Corrective action

Once a problem is identified as to why an image turned out poorly, it's time to take action to fix the issue so it doesn't continue to happen to yourself and others. Correcting a problem may mean studying your positioning guide a bit more, reevaluating the accuracy of a technique chart, or scheduling a piece of equipment for maintenance. No matter what the problem is or how long it may take to correct, don't be afraid to include others (like your supervisor, QA/QC tech, or a more senior technologist) to increase your knowledge and level of skill to produce high-quality images.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

017. Quality assurance in Diagnostic Imaging

1. What is the main focus of quality assurance (QA) programs?

2. Although no law requires it, why is it necessary for hospitals to be accredited by The Joint Commission (TJC)?

3. What is the concept known as if the radiologist's diagnosis ultimately agrees with the patient's disease?

4. When a numerical value is assigned to show the amount of radiation an imaging plate received, what is being represented?

5. What are the *most* obvious benefits of a QA program?

018. Factors affecting image quality

1. What are the three principal geometric factors that affect radiographic quality?

2. How is magnification of a body part controlled during imaging?

3. How is distortion kept to a *minimum* on radiographic images?

4. What kind of focal spot reduces the amount of beam divergence?

5. With regards to the part being imaged, what subject factor characteristics affect image quality?

019. Artifacts

1. What is an artifact?

2. How should collimation be performed for computed radiography (CR) histograms to correctly read the edges of the exposure field?

3. What are three things that can cause scanner malfunctions?

4. What kind of artifact is seen when *not* all of the latent image data is cleared from the imaging plate during the erasure phase of processing and a subsequent exposure is made?

020. Image quality control and evaluation

1. How many basic questions can you ask yourself when critiquing an image?

2. Give three reasons when an image may need to be repeated.

3. Name the three categories the majority of quality problems fit into.

4. Why is it important to control the geometric exposure factors?

4–2. Quality Control

In this section we examine QC within radiography. QC is the aspect of the QA program that monitors the equipment used to produce quality images. The concept of QC is rooted in the need to stabilize the various equipment components of the radiographic imaging chain. The QC program is important because technical expertise will not guarantee success in radiography unless the equipment is consistently performing in a reliable manner. Additionally TJC verifies that organizations have programs in place to monitor the effective performance of radiation-producing equipment.

We explore the needs and benefits of a QC program and explore what is necessary to make a program successful. Keep in mind that this is only a brief introduction into quality control for it is not possible in this course to detail procedures for all the numerous tests performed on radiographic equipment to assure proper function. Some QC techniques are discussed more thoroughly in later lessons in this course.

021. Quality control in diagnostic imaging

QC consists of planned and systematic actions giving adequate confidence that radiologic equipment will produce consistently high-quality images with minimum exposure to patients and medical personnel. Imagine all of the radiographers in a department were of the highest caliber in expertise and training, but the department still had a high repeat rate due to equipment failure. The facility producing the images makes a determination of what constitutes high quality. A medical physicist usually establishes quality guidelines for equipment, while the chief radiologist determines the

standard for quality exams. Many of the requirements to run the QC program are assigned as an additional duty to a competent noncommissioned officer (NCO) or a designated QC technologist within the department.

Quality control program

A QC program is an organized, systematic approach designed to monitor and control the quality of operation for key equipment components in a DI department. The nature and extent of the program will vary with the size and type of facility, type of equipment used, available personnel, and resources. QC tests should be routinely performed on X-ray system components, such as the collimator, generator, focal spots, display monitors, and PACS. At larger facilities a medical physicist performs these tests, whereas at smaller facilities, you could perform them at some point. QC tests are specific, documented procedures used to monitor or test the operation and effectiveness of the components of a radiographic system. Thus QC tests are concerned *directly* with the equipment, *not* personnel or processes.

Quality control documentation

Individuals in charge of QC programs are entrusted to check QC monitoring tests are properly performed and evaluated and that necessary corrective measures are taken in response to test results. Administrative procedures set the organizational framework for a QC program. Administrative procedures include documenting QC test results and maintaining a QC manual. Documenting the results of QC tests, problems discovered, corrective measures taken, and the effectiveness of those measures is critical to the QC process. Proper documentation is critical because it creates a method of spotting trends and establishing baselines, or benchmarks, for test results. Forms used for this purpose may be developed locally to fit your specific needs. Record-keeping is as important as the QC checks themselves.

Quality control manual

Each radiology department should have a QC manual. The contents are determined by each facility based on local needs, but the items as follows may be included:

1. List of those responsible for monitoring and maintaining equipment.
2. List of the parameters to be monitored and the frequency of monitoring.
3. Description of the standards, established quality criteria, or limits of acceptability (a range of normal values).
4. Brief description of the procedures to be used for monitoring each parameter.
5. Description of procedures for notifying appropriate personnel of any detected problems.
6. List of publications where detailed instructions for monitoring and maintenance procedures can be found.
7. List of records the department has decided to keep and the length of time these records should be retained before disposing.
8. Copy of each set of purchase specifications developed for new equipment and the results of the acceptance testing for the equipment.

Need for quality control

Many radiology departments that don’t have an active QC program experience a high percentage of rejected or repeated radiographs. More often than not, an analysis of substandard images indicates poor equipment performance as a significant cause of repeated images. Problems may arise in any part of a radiographic system.

A QC program should eliminate many of the problems causing poor quality images and detect subtle changes in equipment operation so that problems can be corrected before they affect the quality of the radiographs produced. A QC program does not consist of only making measurements, recording the

data, and filing the results. If the results are not periodically evaluated and corrective action taken when unacceptable areas are found, then all the efforts expended have been wasted.

Aside from the obvious benefits to patient care, a QC program serves several other important functions. For example accurate QC records are often required to defend against lawsuits involving medical imaging. Also some insurance companies only pay for services from radiology departments with approved QC programs. In addition TJC requires facilities to have an ongoing QC program for accreditation.

The Department of the Air Force (DAF) has also recognized the importance of a radiology QC program. Directives from DAF Headquarters offer guidelines for QC, and Air Force policy states that all medical and dental treatment facilities must develop and maintain a QC program.

Benefits of quality control

It usually doesn't take long after establishing a QC program before you begin to see its benefits. The impact of a properly executed QC program is usually expressed in terms of a *reduction* in the repeat rate. Reducing the repeat rate is a direct indication that unnecessary radiation exposure and operating costs have been reduced. Such reductions also indirectly indicate an overall improvement in image quality. Additionally evidence shows a properly working QC system will reduce equipment downtime, which can decrease the wait time a patient incurs.

Responsibilities for quality control

The concepts of QM contain many responsibilities held by every member of a radiology department. Some people have varying levels of responsibility but everyone is important in checking the quality of care that the patient receives remains as high as possible while the radiation dose remains as low as possible. A clear assignment of responsibility with the authority to carry out the responsibility is essential to the success of a QC program.

Radiologist

The radiologist has the primary responsibility for quality administration; however, responsibility for managing the QC program is usually delegated to the superintendent or NCOIC.

Medical physicist

The medical or radiation physicist focuses on training, research, equipment, and radiation safety within a department. The physicist performs QC testing twice a year or annually and has the following obligations:

- Performs acceptance testing on new equipment and reviews departmental images to establish baseline value.
- Checks exposure indicator's accuracy with calibrated ion chambers.
- Determines exposure trends.
- Analyzes repeat rates.
- Reviews QC records.
- Analyzes service history for routine maintenance and repairs on equipment.

Superintendent/NCOIC

Superintendents and NCOICs verify the QC program is carried out as directed by Air Force policy. Additionally it is typical to assign a NCO the responsibility to see that QC documentation is being properly recorded and maintained, to report equipment malfunctions to the MERC or other authorized equipment maintenance personnel, and to work closely with equipment maintenance personnel to develop new equipment requirements as needed.

Technologist

The technologist plays the largest role in the actual execution of the QC program. The most important role of the technologist is to visually inspect and recognize potential problems as they happen and then bring the problems to the attention of his or her NCOIC or MERC. Many problems can be spotted through periodic equipment inspections; however, most issues are identified throughout daily operations.

Periodic *visual* inspection of equipment is an inherent responsibility of *every* staff technologist. It must be performed on a regular basis to help prevent equipment breakdowns. Visual inspection of the mechanical and electrical characteristics of the X-ray system includes:

- Checking the condition of cables.
- Assuring cleanliness of the X-ray room.
- Listening for unusual noises in the moving parts of the system.
- Visually inspecting image receptors every time they are used.
- Checking that digital processing systems maintain their connection to PACS.

Service personnel

MERC and outside professional service technicians perform routine preventive maintenance (PM) according to the manufacturer's recommended schedule. Routine PM includes calibration, cleaning and maintaining internal components, and regular inspection and replacement of any parts that routinely wear out or fail.

022. Monitoring radiographic system components

A radiographic system is an assemblage of components for the controlled production of diagnostic images with X-rays. It includes, at a *minimum*, a high-voltage generator, X-ray control console, tube/housing assembly, beam-limiting devices, and the necessary supporting structure. Ancillary components, such as image receptors, image processors, and image display workstations, are also part of the system.

Types of testing

There are three areas on which QC tests are performed: acceptance testing, routine maintenance, and error maintenance.

Acceptance testing

Acceptance testing is performed on new equipment before the DI department (or MERC) accepts the piece of equipment. The tests performed are designed to ensure the equipment item is and will perform according the manufacturer's specifications. A medical physicist, BMET, or service professional employed by the facility normally performs acceptance testing.

Routine maintenance

A BMET or other service professional performs periodic routine maintenance, sometimes quarterly but at least annually. This is most times referred to as preventive maintenance and its purpose is to verify the piece of equipment continues to perform up to specifications over the lifetime it is in service. It is typical that during PM, problems are identified and able to be corrected, preventing a catastrophic equipment failure.

Error maintenance

When equipment errors occur, the piece of equipment may slow down, perform inadequately, or fail to function altogether. If error codes are displayed on the piece of equipment, make sure to write them down and pass them onto the BMET or service professional.

Monitoring equipment performance

A routine QC program using state-of-the-art procedures should be established and conducted on a regular schedule. The purpose of monitoring equipment is to evaluate the performance of a facility's X-ray systems in terms of image quality standards established by the radiologist in charge and compliance with applicable regulatory requirements described by the physicist.

Each facility determines the specific parameters based on an analysis of expected costs and benefits. Factors, such as the size of the facility, available resources, types of equipment used, and a comparison of QC problems that have occurred in similar facilities, should be taken into account when creating a QC program. The monitoring frequency should be based on need and will vary for different parameters. When a problem is identified with an X-ray system component, *increase* the monitoring frequency for that parameter temporarily to confirm the corrective measures taken were effective.

It is not within the scope of this course to list or describe step-by-step procedures for every type of QC test. The monitoring tests for the components of an X-ray system are too numerous and differ widely according to the type of equipment used. Therefore, refer to the manufacturer's publications for each item of equipment used in your DI department, as well as publications providing general guidelines for radiographic QC techniques. The National Technical Information Service (NTIS), a division of the US Department of Commerce, has publications that may be requested pertaining to radiographic equipment QC procedures. Visit the NTIS website at http://www.ntis.gov for more information and methods of contacting them.

Areas to monitor within a digital imaging system

Many additional sources offer guidelines for performing monitoring tests. Regardless of which references you use, consider these five areas to monitor within a digital imaging system: (1) monitor quality, (2) speed tests, (3) digital data integrity, (4) image receptors, and (5) basic performance characteristics of a radiographic unit.

Monitor quality

Monitors are used to view every digital image of every exam for every patient. Just like in digital cameras, the greater the megapixel value the better the resolution of the pictures you take. In essence the same theory is true with monitors. Radiologists' reading stations typically have the highest resolution monitors ranging from 3–5 megapixels (MP); however, it still depends on what kinds of studies are being read. For example many medical facilities and governing entities state a *minimum* of 5MP monitors for interpreting digital mammography and pediatric radiographic images. For general viewing of radiographic images though, it is not yet cost effective to have the highest resolution monitors (greater than or equal to 5MP) everywhere in the medical facility. Monitor QC tests are recommended to verify the clarity of the image and that the monitor is performing up to its capabilities. Outlined are two types of QC tests routinely performed on radiographic viewing monitors.

NOTE: Reference the operator's manual and/or contact the specific manufacturer before performing QC tests on monitors in your department. The steps outlined in this section are general in nature due to the many different types of monitors used throughout the Air Force.

Daily quality control tests

To perform a typical daily QC test on monitor, do the following:

1. Power on the monitor and allow it to warm up.
2. Clean the monitor's screen of dust, finger prints, and smudges, while also making sure the ventilation areas on the sides/back are cleaned.
3. Using the monitor's owner's manual, follow the instructions to display a Society of Motion Pictures and Television Engineers (SMPTE) test pattern. The test pattern display is a series of

approximately one-inch by one-inch squares, varying in color from white, gray, to black. Other squares have lines of varying widths.

4. View the test pattern looking for abnormalities and inconsistency in the transitions from black-to-white and vice-versa. Look for artifacts and that the vertical/horizontal lines on the pattern look uninterrupted. This step is for visualization of normal image quality and appearance.
5. Evaluate for distortion within the display. Check that the edges of the SMPTE pattern and lines within the squares are all clear and straight.
6. Visualize the 16 luminance patches for clarity. A photometer can be used with this step to measure the luminescence of the *monitor*. This step evaluates clarity, reflection, and noise.
7. To evaluate resolution, look at the pattern displayed on the SMPTE image in the center and at each corner; you should be able to clearly visualize all aspects of the pattern in these areas.
8. Record all results and compare them to the manufacturer's specifications.

Monthly quality control tests

To perform a typical monthly QC test on a monitor, do the following:

1. Power on the monitor and allow it to warm up.
2. Clean the monitor's screen of dust, fingerprints, and smudges, while also making sure the ventilation areas on the sides/back are cleaned.
3. Display the SMPTE test pattern on the screen.
4. Evaluate for geometric distortion by visualizing the test pattern from a typical viewing distance. From side-to-side and at the edges, the pattern should appear linear.
5. Visually check for reflection of other light sources within the parameters of the display. If a mirroring effect of other light sources is visualized, then dim, redirect, or turn off other lights in the room.
6. Use a photometer and check the luminescence reading for each pattern at the center of the monitor. Do the same with the monitor powered off; record both values. Liquid crystal displays (LCDs) should have a value of greater than 170 candelas per square meter (cd/m^2).
7. Check the resolution by using the magnifying glass within the PACS software. You visually evaluate the line patterns for clarity and brightness. Pay attention for any visual anomalies within the line patterns.
8. Record all results and compare them to the manufacturer's specifications.

For both tests, discuss the findings with a medical physicist for evaluation of results and/or further testing.

Speed tests

The speed at which you are able to perform your job is always evaluated. This includes the digital equipment used to perform your everyday tasks. As a part of the QC program, the workstation's processing speed and image retrieval/transfer rate should be evaluated *monthly* to identify negative trends. The following outlines a 4-step process for evaluating your workstations' processing speed:

1. Choose a patient study with multiple images in the folder.

   NOTE: Use the same study each time this test is performed.

2. Use a stopwatch, open the study, and record the time it takes to display the first image. Next scroll through the images one by one; again use the stopwatch to time how long it takes each image to be displayed.
3. Choose a function of the processing software like stitching or edge-enhancement. Perform the function and time how long it takes the software to complete the task.
4. Open a second study from the same patient; note the time it takes for this new study to load.

Record all findings in a notebook or an electronic spreadsheet. Input the results each month and compare to previous months. Look for longer load times and/or indications of processor lag. Report your findings to the PACS administrator for possibly further testing, evaluation, and resolution when necessary.

Performing the second speed test is related to the speed at which an image will transfer from a modality to PACS and from archival back to the workstation. These steps can be used to evaluate transfer speeds:

1. Choose a patient study with multiple images in the folder.

   NOTE: Use the same study each time you perform this test, and perform the test on the same day of the month and roughly the same time of the day to keep network variables the same.
2. Using a stopwatch, time how long it takes to retrieve a study from an archived state to the active files on the workstation for viewing.
3. Transfer speed evaluation. Have each modality in the department send images to archival. Note the time it takes to transfer the studies with a stopwatch. To ensure consistency month after month, send the same set of images each month when transfer speed is tested.

Again record all findings in a notebook or electronic spreadsheet. Compare the recorded transfer times from month to month to identify inconsistencies in the network related to transfer speed. Report your findings to the PACS administrator for possibly further testing, evaluation, and resolution when necessary.

Digital data integrity

Data integrity QC testing makes sure all the digital images acquired at each modality actually make it to PACS. Most leaders around the Air Force require that this task be completed daily to ensure no image is lost. To complete this QC test, use the Composite Health Care System (CHCS) to retrieve a list of all exams performed for the day and then compare the list of exams to what is on PACS. Make sure you pay attention to the file size and number of images in the study. One problem sometimes noted is the patient's folder will be on PACS, but no images will be in the folder. If this is the case, resend the images from the QC workstation to PACS. If again no images appear, notify your PACS administrator for assistance, and let the radiologist know the issue is being worked on.

Image receptors

A category accounting for many artifacts and problems with producing quality images is attached to the care and condition of IRs. CR uses cassettes with image plates inside, similar to conventional cassettes with film inside. DR, on the other hand, has advanced DI so the IR is actually part of the X-ray imaging system in the form of a table- or wall-bucky. Each of these systems requires routine inspection and cleaning of the IRs to make certain your department consistently produces high-quality exams.

Computed radiography image receptors

For a CR X-ray imaging system, the following QC schedules are recommended:

Daily	Weekly
Inspect all aspects of the cassette housing to include hinges and latches for properly function.	Inspect and clean each image receptor (imaging plate) for damage and foreign objects.
Clean all cassettes with an approved cleansing agent/disinfectant.	Clean the CR reader air intake vents to prevent dust particles from getting in the processor.
Perform the erase feature on all imaging plates to remove any remnant or scatter radiation.	Wipe the monitor, keyboard, and mouse for all stations.

During the daily inspection of the IR cassette housing, you double-check the imaging plate barcode is adequately displayed through the window in the cassette housing, test that there is enough tension in the open/close mechanism spring to properly secure the cassette door, and inspect the cassette door hinges so the door opens freely and allows smooth removal of the imaging plate when in the reader. Each CR cassette should be wiped clean at least daily and whenever the cassette comes in contact with a patient during an exam. For example if barium or IV contrast media is on the exposure side of the cassette, these substances will absorb photons and cause reduced image quality. Each morning at the start of your department's day shift, each cassette should be run through the CR reader to have the imaging plate appropriately erased of any remnant or scatter radiation that may be present on any of IR in your holding bin. Performing daily QC on the CR cassettes will make sure the IRs are in good working order and clean of debris to produce high-quality radiographic images.

On a weekly basis, once completing your visual and functional inspection of the cassettes, proceed to inspect the imaging plates. Inspect the imaging plates for cracks, other damage, or foreign objects like dust, dirt, or hair, all of which can degrade quality on your finished image.

To clean the imaging plate, you must do the following:

1. Remove it from the cassette, and place it on a soft, lint-free surface. You will need to handle the imaging plate by the edges and refrain from touching the white phosphor side of the imaging plate. Do not bend, squeeze, or drop the imaging plate.
2. For periodic routine cleaning, use a lint-free cloth or camelhair brush to wipe all dust and debris off the imaging plate's phosphor side. If dust or dirt is not removed easily, then do not force it.
3. Apply the manufacturer's recommended cleaning solution to a lint-free cloth, and softly wipe the dirt off the white phosphor side of the imaging plate. Do not scrub in a back-and-forth motion; instead, clean the imaging plate starting in one corner and wiping laterally to the other side. Continue to wipe laterally from top to bottom on the imaging plate.
4. After wiping the entire imaging plate, make sure you use a dry, lint-free cloth to wipe and absorb any excessive cleaning solution.
5. Allow the image plate to air dry before placing it back in the cassette housing.
6. Run the cassette through the CR reader to erase the imaging plate before using with a patient's exam. Other weekly tasks to be done in conjunction with the QC program include cleaning the air intact vents on the CR reader/processor. This will reduce the amount of dust and dirt particles induced into the processor, which could potentially cause an artifact. In addition wipe the viewing monitors, keyboards, and computer mouse at each processing and viewing workstation.

Direct radiography image receptors

DR X-ray systems include an IR array system that is built into the table- or wall-bucky. For this reason DR is known as cassette-less radiography. Some DR systems are closed systems; therefore, access to the IR is restricted to authorized service personnel only. Other DR systems use an IR that

can be positioned in the table- or wall-bucky, depending on the exam you are performing. For this type of DR X-ray system, daily QC inspection and cleaning of the IR is necessary for proper function, cleanliness, and safety. When cleaning a corded DR IR, first inspect it for damage. Next inspect the cord for kinks, cuts, or exposure of any wires. Pay special attention to the ends of the cord where connections are made to the main unit or IR. If damage is found to the IR or the cord, report it to your NCOIC and MERC immediately for repair. Failure to report any damage to the IR assembly could result in electrical shock, electrical current shorts, or image noise.

It is best to make a habit of cleaning and inspecting DR IRs at the beginning of your duty day before starting patient care. Throughout the day it may be necessary to clean the IR in between patients due to blood and bodily fluid exposure.

Cleaning a DR IR is not complicated. Use the approved disinfectant wipe for your facility to clean the outside surfaces of the DR IR. Wipe the cord as well, if applicable. Keeping your equipment clean increases image quality and presents a positive environment that helps set your patients mind at ease when entering the X-ray suite. No patient feels comfortable entering a dirty or unorganized X-ray suite.

Basic performance characteristics of an X-ray unit

Monitoring tests for radiographic units are numerous, and the types of procedures to be performed depend on the type of radiographic unit you are testing. In other words there are different QC techniques for fluoroscopic units, mammographic units, computed tomography units, and regular radiographic units; however, at a *minimum*, these tests should be performed:

QC Tests for X-ray Units	
Type of Test	**Recommended Minimum Frequency**
Reproducibility of X-ray output (exposure)	Annually
Linearity of mA stations	Annually
Accuracy of exposure timer	Annually
Calibration of kVp stations	Annually
Accuracy of collimator	Twice annually
Focal-spot size	Annually
Beam quality	Annually

Most of the QC tests performed on X-ray imaging systems are performed by qualified BMETs, a medical physicist, or equipment service personnel. When the opportunity presents itself, ask your NCOIC and the person doing the specific QC test if you can help do the tests with them so you can learn more about the various QC tests completed to produce high-quality images.

023. Repeat image analysis

A repeated image analysis is a study determining the quantity and reasons for repeated images. A repeated image, often termed a “repeat,” “reject,” or a “retake,” is considered any radiograph that was performed a second (or more) time due to some error, breakdown, or degradation in the radiographic process that affected the finished product being deemed a less than quality image. Repeat analysis studies are an integral part of any properly run QM program. Information from the analysis can help you determine what areas of your QM program deserve more attention to improve efficiency within a DI department. In digital radiography the primary benefits that come from a repeat image analysis are increased department productivity, increased customer satisfaction, and decreased patient radiation exposure doses.

Benefits

Whenever repeat rates are low, it decreases the time needed to complete the patient's exam. Decreasing the time needed to complete an exam increases the amount of patients that can be imaged in the same time period, thus increasing department productivity and customer satisfaction. Another benefit of a repeat image analysis is patients getting exposed to less ionizing radiation, which, as previously stated, is a primary goal of any QM program. Reducing the patient's radiation exposure dose is the result of lower repeat rates due to the analysis identifying areas for improvements by means of training and/or equipment maintenance.

Performing a repeat image analysis

Most literature states a repeat image analysis be performed monthly as a part of a well-managed QC program. The *purpose* of performing a repeat analysis is to analyze if any QC problem areas exist or are developing in your department. A repeat analysis collects data regarding the specific image repeat reason, amount of repeats, and the imaging tech accountable for the repeated image(s). A repeat image analysis is *not* used to specifically single out and discipline poor performing techs. The following are normal areas used to categorized rejected/repeated images: positioning errors, overexposure or underexposure (use the S-number for determining this), patient motion, artifacts, processing errors, and mechanical issues.

Gathering the data

Performing a repeat image analysis with a digital imaging system is normally a matter of gathering data from the software. Most manufacturers have mechanisms built-in to their software in which QC techs can mark images as rejected (less than quality) for a specific reason (like mentioned above). In addition the radiologist can also mark images they receive with quality improvement flags. QC personnel can then retrieve and review these mark images later. This step, involving QC techs and radiologists marking images, is important in identifying training needs for future in-service briefings designed to improve image quality and reducing the amount of radiation exposure the patient receives.

Calculating repeat rate percentage

Repeat rates can be determined for the department as a whole and individually. Within digital systems your PACS administrator should be able to provide you with a count of total images conducted by the department as a whole or individually within a period of time, as well as how many images were rejected. Plug the numbers into the following formula to obtain the department or individual repeat rate.

$$\text{Repeat Rate (percent)} = \frac{\text{Number of repeats}}{\text{Number of images completed}} \text{ X } 100$$

The percentage of repeated images, or repeat rate, can be determined for any period (week, month, or year) by dividing the number of repeated images by the total number of images completed and then multiplying it by 100 to end up at a percentage. For example suppose your department completed 5,700 radiographic images and had 515 repeats during that time. The repeat rate would be calculated this way:

$$\text{Repeat Rate} = \frac{515}{5{,}700}$$

$$\text{Repeat Rate} = 9 \text{ percent (rounded)}$$

Analyzing results

The most important data gained from the reject analysis is the distribution of reasons for rejecting images. It is *very* common in digital departments to find that *positioning errors* are the *number one*

cause of rejected images. No matter what though, any large deviation of rejected images in a specific category (body part, reason for rejection, exposure room, or technologist) should be looked at closely to see if a problem exists.

Based off the data acquired, the following needs may be identified:

- Individualized on-the-job training for certain technologists.
- Review of specific body part position for high-repeated exams.
- Topics for continued education or in-service briefings.
- Maintenance for low performing pieces of equipment.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

021. Quality control in diagnostic imaging

1. What is a quality control (QC) program?

2. Why is documentation so critical to the QC process?

3. Where can you find a list of the specific parameters monitored by your department's QC program?

4. What is the Air Force's policy regarding QC programs?

5. Who has the primary responsibility for quality administration in a radiology department?

6. Normally, who is assigned responsibility for seeing the QC program is carried out?

7. What is the *most* important role of the technologist in the QC program?

022. Monitoring radiographic system components

1. In what three areas are QC tests performed?

2. What is the purpose of preventive maintenance?

3. If a problem is identified with an X-ray system component, how should this affect the QC monitoring frequency for that component?

4. List five areas to monitor within a digital imaging system.

5. Why are QC tests recommended on monitors used for viewing radiographic images?

6. What are the first three steps for both the daily and monthly monitor QC tests?

7. What two steps are performed to ensure digital data integrity from a modality to PACS?

8. How often should a CR cassette housing be inspected and cleaned?

9. Why should daily QC be performed on CR cassettes?

10. How often and why should a corded IR for a DR X-ray system be inspected and cleaned?

11. How often should QC tests to measure the X-ray beam quality be performed?

023. Repeat image analysis

1. What are three benefits of a repeat image analysis?

2. How often is a repeat image analysis performed as a part of a well-managed QC program?

3. What is the purpose of performing a repeat image analysis?

4. Why is it important for QC techs to mark an image as rejected or for a radiologist to mark an image with a quality improvement flag?

5. What is the repeat rate for a department that produced 5,000 images in 1 month and had 250 repeats?

Answers to Self-Test Questions

017

1. People.
2. A hospital will not be reimbursed by insurance companies, be able to hold medical licenses, receive malpractice insurance, or host a residency program for physicians if not accredited by TJC.
3. Outcome analysis.
4. The sensitivity of a digital imaging system.
5. Time saved, improved customer service, reduced patient dose, and increased image quality.

018

1. Magnification, distortion, and focal-spot blur.
2. Reduce OID and increase SID.
3. By keeping the X-ray source perpendicular to the body part and IR.
4. A small focal spot.
5. Part size, tissue composition, and shape of the anatomical part.

019

1. Any unwanted items on the finished radiograph.
2. The collimated borders should be parallel with the edges of the imaging plate.
3. Memory problems, digitization issues, and circuit communication errors.
4. Phantom or ghost image artifact.

020

1. Nine .
2. Any of three of the following: (1)Technique too much or not enough, (2) positioning errors, (3) wrong patient identification, (4) no lead anatomical marker or the wrong one was used, (5) anatomy is superimposed, clipped, or missing, and/or (6) an artifact is in the anatomy of the image.
3. Technical factor problems, procedural problems, or equipment malfunction problems.
4. To increase your ability to produce high-quality images and, in turn, reduce the radiation exposure your patients receive.

021

1. It is an organized, systematic approach designed to monitor and control the quality of operation for key equipment components in a DI department.
2. It creates a method of spotting trends and establishing baselines, or benchmarks, for test results.
3. In the department’s QC manual.
4. It states that all medical and dental treatment facilities must develop and maintain a QC program.
5. The radiologist.
6. Superintendents and NCOICs.
7. To visually inspect and recognize potential problems as they happen and then bring the problems to the attention of their NCOIC or MERC.

022

1. Acceptance testing, routine maintenance, and error maintenance.
2. The purpose is to verify the piece of equipment continues to perform up to specifications over the lifetime it is in service.
3. Increase the monitoring frequency for that parameter temporarily to confirm the corrective measures taken were effective.
4. (1) monitor quality, (2) speed tests, (3) digital data integrity, (4) image receptors, and (5) basic performance characteristics of a radiographic unit.
5. To verify the clarity of the image and that the monitor is performing up to its capabilities.
6. (1) Power on the monitor and allow it to warm up, (2) clean the monitor's screen of dust, finger prints, and smudges while also making sure the ventilation areas on the sides/back are cleaned, and (3) display the SMPTE test pattern on the screen.
7. Use the CHCS to retrieve a list of all exams performed for the day and then compare the list of exams to what is on PACS.
8. Daily.
9. Will make sure the IRs are in good working order and clean of debris to produce high quality radiographic images.
10. Daily; for proper function, cleanliness, and safety.
11. Annually.

023

1. Increased department productivity, increased customer satisfaction, and a decrease in the patient's radiation exposure dose.
2. Monthly.
3. To analyze if any QC problem areas exist or are developing in your department.
4. To identify training needs for future in-service briefings designed to improve image quality and reduce the amount of radiation exposure the patient receives.
5. 5 percent.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

53. (017) What is the concept in which the ultimate *goal* of every DI department is that radiologist's diagnosis agrees with the patient's condition?
    a. Virtual results.
    b. Outcome analysis.
    c. Report resolution.
    d. The Joint Commission's 10-step process.

54. (017) What is *not* a benefit of a properly managed quality assurance program?
    a. Reduced exam times.
    b. Reduced patient dose.
    c. Improved customer service.
    d. Improved workstation speed.

55. (018) Distortion is controlled by
    a. using a parallel central ray.
    b. using a perpendicular central ray.
    c. increasing object-to-image distance.
    d. decreasing subject-to-image distance.

56. (018) Which factor affects selective absorption?
    a. mA.
    b. OID.
    c. SID.
    d. kVp.

57. (019) What kind of problem is caused by selecting the wrong digital system histogram protocol?
    a. Image brightness errors.
    b. Scanner malfunction.
    c. Printer malfunction.
    d. Heat blur errors.

58. (019) Which type of X-ray imaging system is more sensitive to scatter radiation?
    a. Fixed.
    b. Digital.
    c. Mobile.
    d. Conventional.

59. (020) What is *not* a reason to repeat a radiographic image?
    a. Positioning error.
    b. When you see an incomplete fracture.
    c. When anatomy is superimposed, clipped, or missing.
    d. Left anatomical marker used on the patient's right side.

60. (020) The *majority* of image quality problems fit into what three categories?
    a. Network, technique, or histogram.
    b. Processing, exposure, or connectivity.
    c. Technical, procedural, or equipment.
    d. Geometric, positioning, or technologist.

61. (021) Quality control tests are designed to measure the effectiveness of
    a. radiology personnel.
    b. radiologic processes.
    c. radiographic equipment.
    d. radiographic examinations.

62. (021) Which is a benefit of a properly executed quality control program?
    a. A reduction in the repeat rate.
    b. An increase in operating costs.
    c. An increase in patient satisfaction.
    d. A reduction in patient waiting times.

63. (022) Which type of testing involves ensuring a piece of equipment performs up to specifications over the lifetime it is in service?
    a. Periodic.
    b. Regular.
    c. Routine.
    d. General.

64. (022) When a routine quality control (QC) test identifies a problem with a radiographic system component and corrective measures are taken, the monitoring frequency for that component should
    a. remain the same.
    b. decrease to allow for break-in of the new parts.
    c. stop for the warranty period of the replacement parts.
    d. increase to ensure the corrective measures taken were effective.

65. (022) When performing a quality control (QC) test on radiographic system component, a photometer is used to measure the luminescence of
    a. reading room overhead lights.
    b. imaging plates.
    c. monitors.
    d. contrast.

66. (023) You do *not* conduct a repeat image analysis to
    a. hold technologist accountable for repeated images.
    b. determine if any quality control problems exist.
    c. single out and discipline poor performing techs.
    d. identify training needs.

67. (023) What is the repeat rate for a department that performed 5,400 exposures and had 270 repeated images in one month?
    a. 0.5 percent.
    b. 5 percent.
    c. 20 percent.
    d. 22 percent.

68. (023) What is a technologist's repeat rate if they performed 500 images and had 35 rejected images in one month?
    a. 5 percent.
    b. 7 percent.
    c. 10 percent.
    d. 14 percent.

69. (023) In a digital department, what is the *most* common cause of rejected images?
    a. Technique errors.
    b. Quantum mottle.
    c. Positioning errors.
    d. Scanner malfunctions.

Student Notes

Glossary

Terms

Antimicrobial—Destructive to microorganism.

Asepsis—Absence of infection.

Defamation—False or unjustified acts or statements that damage the good name or reputation of another.

Fomite—An infectious object.

Flora—Microorganisms that are adapted for living in a specific environment.

Helminths—A worm-like animal (often parasitic).

Nosocomial infection—Infections acquired in a hospital.

Pathogen—Any organism capable of causing disease.

Pecuniary—Pertaining to or consisting of money.

Respondeat superior—Let the master respond.

Sepsis—Infection.

Vectors—Insects and rodents that transmit disease.

Virulence—A measure of the ability of the organism to invade host tissues, withstand defenses, and cause infection.

Abbreviations, Acronyms, and Symbols

ADC	analog-to-digital converter
AFMS	Air Force Medical Service
AFRIMS	Air Force Records Information Management System
Agfa	Agfa-Gevaert company
AIDS	acquired immunodeficiency disease syndrome
ALARA	As Low As Reasonably Achievable
AP	anterior-posterior
ARRT	American Registry or Radiologic Technologists
BCO	base contracting office
BMET	biomedical equipment repair technician
BPA	blanket purchase agreement
CAIM	customer area inventory management
CAL	custodial action list
CD	compact disk

CDC	Centers for Disease Control and Prevention
cd/m^2	candelas per square meter
CDC	Centers for Disease Control
C-diff	clostridium difficile colitis
CHCS	Composite Health Care System
CONUS	continental United States
CPR	cardiopulmonary resuscitation
CR	computed radiography
CR/LL	custodian receipt/location list
CT	computed tomography
DAF	Department of the Air Force
DEERS	Defense Enrollment Eligibility Reporting System
DI	Diagnostic Imaging
DLA	Defense Logistics Agency
DMLSS	Defense Medical Logistics Standard Support
DNA	deoxyribonucleic acid
DNI	do not intubate
DNR	do not resuscitate
DOD	Department of Defense
DR	direct radiography
EPA	Environmental Protection Agency
ERAA	equipment review authorization activity
FOUO	for official use only
FTCA	Federal Tort Claims Act
GPC	government purchase card
GS	general schedule
GSA	General Services Administration
ICU	intensive care unit
IR	image receptor
IV	intravenous
JCAHO	Joint Commission on Accreditation of Healthcare Organizations
kVp	kilo-voltage peak
LCD	liquid crystal display
LgM	log median exposure

LP	local purchase
MAJCOM	major command
mAs	milliamperage and time
MDG/CC	medical group commander
MEMO	Medical Equipment Management Office
MERC	Medical Equipment Repair Center
MP	megapixel
mR	millirad
MRSA	methicillin-resistant staphylococcus aureus
MTF	medical treatment facility
NCO	noncommissioned officer
NCOIC	noncommissioned officer in charge
NPRC	National Personnel Records Center
NSN	national stock number
NTIS	National Technical Information Service
O&M	operations and maintenance
OIC	officer-in-charge
OID	object-to-image distance
OJT	on-the-job training
OSHA	Occupational Safety and Health Administration
PA	posterior-anterior
PACS	picture archiving and communication system
PC	personal computer
PII	personal identifiable information
PM	preventive maintenance
QA	quality assurance
QC	quality control
QM	quality management
RMO	resource management office
RNA	ribonucleic acid
ROS	report of survey
SARS	severe acute respiratory syndrome
SID	subject-to-image distance
SMPTE	Society of Motion Picture and Television Engineers

S-number	sensitivity number
SOP	standard operating procedures
SSN	social security number
TIGERS	The Integrated Global Equipment Request System
TJC	The Joint Commission
VA	Veterans Administration
VRE	vancomycin-resistant enterococci

Student Notes

AFSC 4R051
Z4R051 01 0316
Edit Code 03