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- Check out the sample ballot on pages 293-295 to see who is running.
- Read candidate profiles and position statements for president-elect, vice president and secretary-treasurer as well as chapter delegate candidate profiles.
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ASRT Office
15000 Central Ave SE
Albuquerque, NM 87123-3909
Phone: 800-444-2778, Fax: 505-298-5063
www.asrt.org

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ON THE COVER

“Orbs 2014” is the third cover by Bergés Alvarez, MD, R.T.(R)(T) (QM), of Bellmore, New York. “This image represents our passageways,” he says. “We arise from our blue-brown earth into a light, fluid existence that we float in all our lives. Softly cradled in snow-globe orbs and channeled by our spirit guides, we again resurface as enlightened creatures...”
Editor’s Note

Be Heard

Alicia Kellogg, MA

This issue of Radiologic Technology brings you everything you expect from your ASRT journal—the latest peer-reviewed original research in your field to keep you informed, Directed Reading articles that provide the continuing education credit you need, and practical information you can use in your work today. But this January/February issue offers a little something extra.

Starting on page 293, you’ll find a sample ballot for the upcoming ASRT election. The ballot includes candidates for the 3 national officers who will serve on the ASRT Board of Directors, as well as candidates for the chapter delegates who will serve in the House of Delegates. These individuals are leaders in the profession and voices for the growing, changing, multifaceted practice of medical imaging and radiation therapy. The annual election is all about getting involved in your profession, and this issue’s sample ballot will help you do just that.

You can use the sample ballot along with ASRT’s extensive content about the candidates—including profiles, position statements, videos, and interactive online resources—to see who is running and to become informed so when voting in the 2014 election starts on February 13, you’ll be ready to cast your vote. The polls will be open from February 13 to March 13, 2014. Visit www.asrt.org/vote for more information, and watch for your next issue of ASRT Scanner, which will feature detailed election coverage.

Health care is on everyone’s mind as the Patient Protection and Affordable Care Act kicks off on January 1. As this issue reaches mailboxes across the country, the U.S. health care system is in the midst of arguably the most significant shift since the mid-1960s, when the Medicare and Medicaid programs were initiated.

This issue features the Directed Reading article “Medicare Reimbursement: What R.T.s Should Know,” by ASRT’s Chief Governance and Development Officer Liana Watson, DM, R.T.(R)(M)(S)(BS), RDMS, RVT, FASRT. The article provides an overview for the medical imaging professional of how the Medicare program works—the information you need as the Affordable Care Act takes effect.

The start of 2014 offers new opportunities to stay informed, get involved, and take action. We thank you for bringing Radiologic Technology along for the ride.

Alicia Kellogg, MA, has 10 years of publication editing experience and now serves as managing editor of Radiologic Technology for the American Society of Radiologic Technologists.
Medical Radiation Dose Perception and Its Effect on Public Health

Quentin T Moore, MPH, R.T.(R)(T)(QM)

**Purpose** To determine whether public health implications exist in regard to medical radiation exposure.

**Methods** A comprehensive literature review was conducted to investigate the value of medical imaging procedures that use ionizing radiation and the need for public radiation awareness. The significance of radiation exposure on public health was sought from historic and modern perspectives.

**Discussion** Potential issues involving medical imaging procedures that use ionizing radiation were identified. Ionizing radiation, effective dose, and radiation perception were investigated from a multimodality perspective to demonstrate the importance of radiation awareness.

**Conclusion** Medical imaging’s role in health care dictates the need for quality and competence. Organizational efforts have enhanced radiation risk knowledge, but medical imaging facilities should augment employee and public knowledge regarding medical imaging procedures. To change public perception of radiation, technologists should be prepared to discuss imaging benefits and risks, understand dose associated with different modalities, and implement radiation dose protocols. The findings reveal the importance of monitoring ionizing radiation medical imaging safety to maintain the benefits of imaging procedures.

Media attention regarding medical radiation issues has created a public health scare. Beginning in 2009, Walt Bogdanich wrote a series of *New York Times* articles that examined issues arising from the increasing use of medical radiation and the new technologies that deliver it. The series raised public awareness about the dangers of medical radiation with captivating headlines such as “Radiation Overdoses Point Up Dangers of CT Scans,” “As Technology Surges, Radiation Safeguards Lag,” “After Stroke Scans, Patients Face Serious Health Risks,” and “X-rays and Unshielded Infants Raise Alarms.”

More recently, media outlets have reported that computed tomography (CT) scans of children could raise their cancer risk slightly. These reports stem from a Pearce et al study published in *Lancet.* This attention has created public fear and apprehension toward medical imaging procedures that produce ionizing radiation.

This literature review reflects on the value of diagnostic imaging, attempts to determine whether medical radiation is a public health concern, and explains the role of health organizations in radiation education and safeguards. This information should help radiologic technologists, administrators, and educators make informed decisions regarding safe medical imaging practices to control public radiation dose. Emphasis should be placed on the value of medical imaging while conveying the need for radiation awareness and dose monitoring.

**Methods**

A search of the literature was conducted using the MEDLINE research database, a subset of the PubMed database (National Institutes of Health). A separate search yielded recent information from relevant government and nonprofit agencies, such as the U.S. Food and Drug Administration (FDA), Center for Devices and Radiological Health, Environmental Protection Agency, and Radiological Society of North America (RSNA). Medical Subject Heading (MeSH) search terms
In addition, the Atomic Energy Commission sought support for a central repository to contain records of individual yearly doses of 1.25 rem or greater.3 Today, it is the goal of every radiation safety program to protect patients, staff, and the public from unnecessary radiation and keep exposure as low as reasonably achievable (ALARA).4 This is supported in part through the use of collimation and shielding devices now standard in medical imaging and radiology departments. These tools, along with more stringent dose limit guidelines, were implemented to decrease patient radiation exposure.5 Although medical imaging has progressed, many of the same safety issues are present today. A central location for reporting patients’ received dose and imaging history is still in the early stages of development.

Medical Imaging Overview
Medical imaging technologies that use ionizing radiation, including diagnostic radiography, fluoroscopy, and CT, have advanced considerably in the past 20 years. The changes have allowed procedures to evolve from analog 2-D images to digital images capable of window and leveling adjustments, image enhancement, and 3-D reconstruction. Although this has led to greater diagnostic capabilities, public health concerns have grown because of medical errors and the disparity in the amount of radiation each modality uses.1,6 CT is a powerful diagnostic tool, but it requires significantly more radiation exposure to render its images as compared to diagnostic radiography. For example, the adult effective dose from a cranial CT

Discussion
Historical Perspective
During the mid-1950s, concerns started to arise regarding the effects of medical radiation. The properties of ionizing radiation exposure from medical imaging procedures needed to be examined. The field sought to increase benefits to patients while still protecting them from the potential harmful effects of radiation. Questions existed about whether funding should be spent on beam collimators and shields.1

A 1969 report by Saenger found that doses of 1.5 rem to 3 rem could result in an increase of benign or malignant tumors.3 At that time, many proposals were put forth to reduce the 5-rem-per-year maximum permissible dose for patients to 1.25 rem to 3 rem per year.

were used to narrow the MEDLINE results. The word radiology was most often selected as the MeSH major topic and was combined with other MeSH topics (see Box 1). The literature review was not limited to articles published within a specific period, as both historic and current perspectives were sought. Of these articles, 37 provided technical radiation dose information related to medical imaging procedures using ionizing radiation.
examination is equivalent to the adult effective dose of approximately 100 chest radiographs. The adult effective dose from an abdominal CT examination is equivalent to the adult effective dose of approximately 200 to 400 chest radiographs. In 2006, studies suggested that CT and nuclear medicine represented 22% of all medical imaging procedures using ionizing radiation but contributed 75% of the collective radiation dose to patients in the United States.

The higher radiation dose associated with CT procedures must be considered, especially given the advances of imaging modalities that do not use ionizing radiation, such as ultrasonography and magnetic resonance (MR) imaging. In some cases, ultrasonography and MR can replace many procedures with no known adverse effects. Medical imaging procedures using ionizing radiation have improved substantially since their inception, but additional research could yield more improvements and assist in managing radiation usage.

**Radiation Dose Perception**

Technological improvements in medical imaging equipment that uses ionizing radiation alone will not dictate proper management of public radiation dose. It is equally important to control the potential effects of radiation through dose optimization protocols and explain the need for a medical imaging procedure using ionizing radiation so the patient can make informed decisions. Thus, all personnel, from the ordering physician to the radiologic technologist, must be aware of the risks and benefits of imaging procedures as well as relative patient radiation exposure for various examinations.

A series of separate perception-and-awareness–based radiation dose studies conducted to assess patient and physician knowledge of radiation risks and benefits reflect the need for greater awareness. These studies showed that 7% of patients reported that they were told about risks and benefits of their CT scan, while 22% of emergency department physicians reported that they had provided such information. In one study, 34% of patients were unaware that the scans would expose their bodies to radiation and clearly did not understand the risks. Regarding those risks, 47% of radiologists believed there was increased cancer risk, whereas only 9% of emergency department physicians and 3% of patients believed there was increased cancer risk. Busey et al suggest that patient knowledge about radiation is limited because provider knowledge of radiation is limited.

All patients and most emergency department physicians and radiologists were unable to estimate accurately the dose for 1 CT scan or 1 nuclear medicine study compared with that of 1 chest radiograph. More than one-third (35.7%) of doctors incorrectly believed that typical nuclear medicine studies either do not use ionizing radiation or emit doses equal to or less than a standard chest radiograph. Despite having a poor understanding of these concepts, most practitioners claim to consider radiation exposure prior to requesting scans and when discussing potential risks with patients. It is evident that the use of rapidly evolving medical imaging technology has outpaced the necessary understanding of the doses and risks associated with these technologies. To manage public radiation exposure, physicians and medical imaging professionals should make every effort to enhance personal knowledge to educate patients prior to performing imaging procedures using ionizing radiation.

**Ionizing Radiation**

Explaining ionizing radiation helps the public make informed medical decisions. Ionizing radiation is defined as radiation that has enough energy to displace electrons from atoms inside of a patient. The primary types of ionization radiation are x-rays, gamma rays, and alpha and beta particles. Each type has the potential to cause damage inside individual cells and could lead to adverse health effects in the person exposed or his or her future offspring.

However, it is important to understand that radiation is a natural part of the environment. Statistics from the 1980s to today demonstrate that a person will receive approximately 3.0 mSv from background radiation sources. Historically, the majority of a person’s annual radiation exposure was from radon sources in the environment. While background radiation exposure has remained fairly consistent, increased use of medical imaging that uses ionizing radiation has resulted in greater total radiation exposure to patients. Reasons for these increases include:

- Greater frequency of scanning.
- Easier access to medical imaging.
- Expanded applications of imaging technology.
Studies show that approximately 4500 imaging examinations are performed on 1000 of those enrolled in Medicare per year. These data demonstrate that an individual will undergo an average of 1 to 5 medical imaging procedures using ionizing radiation per year. In general, a 3-fold increase in the number of advanced procedures using ionizing radiation occurred in the past 15 years. Although the risk to an individual from a single examination is likely small, millions of examinations are performed each year. The most frequently cited issue associated with radiation is the link to cancer. The chance of cancer occurring—not the severity of cancer—that increases as the radiation dose increases. Because current research does not reflect a safe level of radiation, exposure must be minimized.

According to a March 2009 report by the National Council on Radiation Protection & Measurements, the total exposure of the U.S. population to ionizing radiation over the past 2 decades has nearly doubled. This rise largely is attributed to increased exposure from higher-dose medical procedures. The council estimates that 67 million CT scans, 18 million nuclear medicine procedures, and 17 million interventional fluoroscopy procedures were performed in the United States in 2006, and it is predicted that these figures will continue to rise. These figures represent a 7-fold increase in the use of CT imaging for the entire population in the past decade. Studies show that approximately 4500 imaging examinations are performed on 1000 of those enrolled in Medicare per year. These data demonstrate that an individual will undergo an average of 1 to 5 medical imaging procedures using ionizing radiation per year. In general, a 3-fold increase in the number of advanced procedures using ionizing radiation occurred in the past 15 years.

The Table shows a definitive increase in individual dose from the 1980s to 2006, indicating that an increase in medical imaging examinations using radiation is the primary reason for annual radiation dose escalation in the population.

<table>
<thead>
<tr>
<th>Effective Dose per Individual in the United States</th>
<th>Early 1980s (mSv)</th>
<th>2006 (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dose</td>
<td>3.6</td>
<td>6.2</td>
</tr>
<tr>
<td>Natural environmental radiation</td>
<td>3.0</td>
<td>3.1</td>
</tr>
<tr>
<td>Medical radiation</td>
<td>0.5</td>
<td>3.0</td>
</tr>
<tr>
<td>Consumer products</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td>Occupational exposure</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Figure 1. Radiography from medical imaging procedures that use ionizing radiation greatly increased in the United States from the early 1980s to 2006. Background percentages are excluded because their inclusion gives the impression that background radiation exposure is reduced today, when it is actually the same. Chart created using data from the National Council on Radiation Protection & Measurements. NCRP report No. 160, ionizing radiation exposure of the population of the United States. http://www.ncrponline.org/Publications/Press_Releases/160press.html. Published 2006. Accessed March 1, 2011.*
sources, consumer products, and occupational sources have remained relatively steady, exposure from medical imaging procedures is an important public health issue.\textsuperscript{7,8,12,20,23} Experts disagree about the extent of the risk from imaging procedures using ionizing radiation, but most agree that the necessity of each examination must be weighed carefully.\textsuperscript{9}

**Atomic Bomb Studies**

In the interest of public health, several significant studies have been conducted to better understand the effects of ionizing radiation. Rationale for these studies is based partially on data researchers collected over time from 70,000 to 80,000 atomic bomb survivors in Hiroshima and Nagasaki, Japan.\textsuperscript{8,10,18} Over the past 50 years, follow-up survivor data indicates 12,000 cases of cancer, of which approximately 700 were the result of radiation exposure from the atomic bombs.\textsuperscript{10} Radiation-induced cancer was significant at doses greater than 100 mSv (~5-10 abdominal CT examinations) for adults exposed to atomic bomb radiation.\textsuperscript{6,24} Most survivors were distant from the direct fallout and therefore exposed to lower levels of whole-body radiation, similar to that received from medical imaging procedures using ionizing radiation.\textsuperscript{10}

The Biological Effects of Ionizing Radiation (BEIR) report used the atomic bomb survivors as its primary source of data. The most recent report, BEIR VII, indicated that a single effective dose of 10 mSv results in a 1 in 1000 lifetime risk of developing radiation-induced solid organ-based cancer or blood-based leukemia.\textsuperscript{25} In particular, the Nuclear Regulatory Commission identified leukemia, breast, and thyroid cancers as the malignancies most associated with medical radiation exposures. Assessing the data on risk from radiation exposure is complicated by the latency period between exposure and development of malignancy (2-7 years for leukemia; up to 20 years for solid tumors such as breast cancer).\textsuperscript{10,12,20}

**Effective Dose and Tissue Sensitivity**

Effective dose is expressed as sievert (Sv) or, for smaller amounts, millisievert (mSv).\textsuperscript{6} To calculate the effective dose equivalent, the sum of the individual dose and a tissue weighting factor are needed. Weighting factors are based on the sensitivity of the specific tissues and organs affected. The effective dose equivalent provides a method for converting localized tissue dose into a whole-body equivalent radiation dose.\textsuperscript{26} Figure 2 compares location-specific radiation doses as well as various medical imaging procedures.\textsuperscript{18}

Tissues and organs have various sensitivities to radiation exposure. The gonads, breasts, and bone marrow are considered among the most sensitive tissues in the body and are termed radiosensitive. Subsequently, tissues such as the heart and muscle that are not as easily damaged are termed radioresistant. The actual radiation risk to different parts of the body from x-ray procedures differs depending on the type, amount, and nature of the tissue irradiated.\textsuperscript{26}

Other factors that must be considered regarding radiation sensitivity include age, sex, patient size, and genetic factors. A developing embryo is most sensitive to radiation—especially in the first trimester.\textsuperscript{7} Infants and children also are highly susceptible to radiation effects, and women are more susceptible than men because of

![Modality Effective Dose Comparison](image-url)
increased breast tissue and gonad location. In addition, the amount of tissue exposed and the location of the radiation exposure can determine potential adverse effects.38

**Dose Reduction Opportunities**

Radiation-induced effects can be reduced by controlling the number and type of procedures performed.39 Imaging often is beneficial, but all patients must understand the benefits and risks of radiologic procedures prior to undergoing them. Once imaging examinations are deemed appropriate for patients, radiologic technologists serve an important role in managing procedural radiation dose. Exposure factors (ie, kVp and mAs) should be determined on a case-by-case basis considering the patient’s age, weight, and most importantly, measured thickness of the anatomic area being examined.4,8,27 Selecting appropriate radiographic parameters in all modalities is crucial, especially for pediatric populations.24-30

Establishing standardized protocols for operation helps to balance image quality and radiation dose. The aim is to minimize the risk without sacrificing or limiting the obvious benefits in the prevention, diagnosis, and cure of diseases.36 The FDA strives to accomplish these goals and advocates the adoption of 2 principles of radiation protection: appropriate justification of the radiation procedure and optimization of the radiation dose used during each procedure.33 FDA initiatives have targeted but are not limited to the 3 types of medical imaging procedures that account for the largest share of patient radiation exposure in the United States: CT, fluoroscopy, and nuclear medicine.31 Initiatives aim for manufacturers of CT and fluoroscopic devices to incorporate important safeguards into the design of their machines.3 In addition, to help reduce radiation exposure among children, the FDA recommended manufacturers design new radiographic imaging devices with protocols and instructions that address specific use for pediatric patients.35 The recommendation proposes that manufacturers that do not demonstrate adequately that their radiation-emitting imaging devices are safe and effective for children include a label on the device that cautions against its use in pediatric populations.32

Some radiologists and medical centers have independently begun to develop and implement stringent radiation protection protocols. For example, Steve Birnbaum, MD, instituted a program that alerts the doctor when a patient aged younger than 40 years reaches 5 CT scans and alerts the patient when that number reaches 10 scans.33 This program is not widely used, but it demonstrates the importance of awareness to patient medical imaging histories and potential radiation-induced effects.

**Organizations Contributing to Change**

Several groups have been instrumental in facilitating radiation awareness. Initiatives such as Image Gently, Image Wisely, and others developed by government and public health organizations have organized efforts to change procedural and ordering habits in medical imaging.34 These organizations often have the common goal of applying ALARA principles to improve the quality and safety of medical imaging procedures that use ionizing radiation. The framework provided by these organizations should be implemented and used in facilities to establish norms and improve medical imaging practice through the management of radiation exposure.

The American College of Radiology (ACR) Appropriateness Criteria are evidence-based guidelines to help referring physicians and other providers make appropriate imaging and treatment decisions. The ACR advocates for strong quality improvement programs overseen by qualified personnel to ensure optimal performance of medical equipment producing ionizing radiation.38 All medical imaging professionals need to be aware of the possible risks that can occur over a patient’s lifetime. Although radiation exposure effects still are debated, education regarding Appropriateness Criteria needs to garner more attention to help limit the number of inappropriate studies.

To further assist in promoting radiation safety, the Image Gently campaign has many educational materials for pediatricians, radiologists, physicists, medical imaging professionals, and parents to encourage the careful use of medical imaging procedures using ionizing radiation on children. The Alliance for Radiation Safety in Pediatric Imaging, which developed Image Gently, conducted social marketing campaigns focused on CT, fluoroscopy, interventional radiography, nuclear medicine, and digital radiography to influence “child-size” techniques and aid in overall
Box 2

Suggestions for Medical Imaging Clinical Practice

1. Understand and be prepared to discuss with patients the benefits and risks of medical imaging procedures that use ionizing radiation.
2. Recognize the dose differences between modalities and the importance of using accurate technical factors.
3. Organize radiation safety planning committees to focus on implementing guidelines and protocols to manage public radiation dose.

Quentin T Moore, MPH, R.T.(R)(T)(QM), is a radiologic technology instructor for Mercy College of Ohio in Toledo. For more information regarding this article, he can be reached at quentin.moore@mercycollege.edu.

Reprint requests may be mailed to the American Society of Radiologic Technologists, Communications Department, 15000 Central Ave SE, Albuquerque, NM 87123-3909, or e-mailed to communications@asrt.org.

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References


awareness of radiation issues present in each modality for pediatric populations. 27-30,34-38

Image Wisely applies many of the same principles of Image Gently to the adult patient population. Materials from Image Gently (www.imagegently.org), Image Wisely (www.imagewisely.org), and RSNA and ACR’s joint Web site (www.radiologyinfo.org) are excellent resources to convey information regarding public and patient safety, imaging studies, and dose management.

Conclusion

This literature review demonstrates that progress needs to be made to educate all medical imaging professionals regarding radiation safeguards for public health. Although radiation procedures often are necessary, they become controversial when ordered in abundance; therefore, guidelines such as the ACR Appropriateness Criteria and Birnbaum’s examination notifications strategy should be further addressed and studied for effectiveness.

As regulatory agencies and medical imaging campaigns develop educational resources, imaging facilities should continually distribute available resources to patients and thoroughly review educational materials on a regular basis as a department. Understanding the resources and developing a comprehensive radiation safety program that addresses equipment, technology changes, and dose and procedure tracking is vital to protecting public health.

Imaging professionals must seek information to combat public fear and misunderstanding of medical radiation. Box 2 outlines key suggestions to address literature findings and implications in clinical practice.
Medical Radiation Dose Perception and Its Effect on Public Health


The Value of Training Technologists for Adverse Reactions to Contrast

Jonelle M Petscavage-Thomas, MD, MPH
Heather Kaneda, DO
Michael A Bruno, MD, FACR

Purpose To design, implement, and measure outcomes of a technologist education program about anaphylactoid reactions to contrast media.

Methods Radiologic technologists viewed a 45-minute presentation and completed a pretest, posttest, and self-assessment. These steps were repeated 14 months later with different test questions. Statistical analysis included participants’ t test to assess significant differences (P < .05) between pretests and posttests.

Results Seventeen computed tomography (CT) technologists participated in the first educational program, and 19 CT technologists participated in the second session. A statistically significant improvement (P < .05) was found between pretest and posttest mean test scores. However, the pretest scores were lower before the second session. Using a Likert scale (1 = completely agree vs 5 = completely disagree), technologists indicated the session improved their knowledge (mean score 1.1), made them more comfortable managing a reaction (mean score 1.1), and fostered confidence in recognizing symptoms of a reaction (mean score 1.4).

Discussion A didactic curriculum of managing anaphylactoid reactions to contrast media offers subjective benefits and short-term objective knowledge gain for CT technologists. After the training, technologists had increased knowledge of and comfort with managing an emergency situation and recognizing symptoms, which help to prevent morbidity and mortality. However, the results indicate that frequent repetition of the material is necessary for long-term gains.

Conclusion A dedicated educational program for technologists helps prevent and manage adverse reactions to contrast media through improved knowledge, increased comfort and confidence, and teamwork development. At a minimum, semiannual training sessions should occur for all technologists to retain knowledge.

Anaphylactoid reactions to iodinated and gadolinium contrast agents are rare but life-threatening events in radiology departments. Previous studies report an overall incidence of anaphylactoid reactions to nonionic iodinated contrast media of 0.2% to 3%, with severe reactions occurring in approximately 0.005% to 0.01% of all injections. At least 4 deaths have been reported from reactions to iodinated contrast media. Thus, prevention and successful management of anaphylactoid reactions through continuing education and standard guidelines should be a critical component of a radiology department’s quality and safety program.

The majority of education focuses on training the resident, fellow, and attending radiology physician. However, the radiologic technologist often is the health care professional responsible for recognizing the symptoms of an anaphylactoid reaction. He or she is the first responder who initiates the management chain and notifies the supervising physician of an emergency situation. The technologist also must supervise the event until the physician arrives to assess and treat the patient.

The number of computed tomography (CT) examinations performed grew to more than 62 million in 2007 compared to only 3 million in 1980, and this number continues to increase each year. Although it is increasingly likely that a technologist will encounter an anaphylactoid reaction to iodinated contrast media during his or her career, many institutions offer no formalized training for technologists in this area.
**Literature Review**

A literature review was performed using various keywords, including contrast media, adverse reaction, anaphylactoid, education, training, regulations, technologists, radiologic, radiology, residents, emergency, simulation, and teamwork. The American Society of Radiologic Technologists (ASRT) and the American Registry of Radiologic Technologists (ARRT) Web sites also were searched for material related to contrast media training and requirements. A study released by the ASRT Education and Research Foundation in 2006 showed that 94.4% of 1550 radiologic technologist respondents were either involved in iodinated contrast administration or supervised others who administered contrast. Thus, contrast media training is crucial for nearly all technologists. Indeed, the ARRT clinical competency requirements state that in CT simulation training, technologists need to “manage patients as situation requires, including monitoring for possible contrast reactions.” In addition, the American College of Radiology (ACR) practice guidelines state that:

> [A]t a minimum, the technologist should understand the general benefits of contrast media administration, follow protocols that involve intravascular injection of contrast media, understand contraindications to intravascular injection of contrast media, and recognize adverse events following contrast media administration.

Annual education and training programs support these ARRT and ACR guidelines. They also are part of an institution’s compliance with reviews and continuing education mandated by regulatory agencies such as the Joint Commission.

A study by Tofil et al showed increased subjective and objective scores of technologists involved with residents in one session of high-fidelity simulation training. However, no other documentation was found in the literature stating the benefits—or lack thereof—of providing technologists with routine, structured contrast media education. Other medical specialties have advocated the benefits of education in the form of a team approach to handling medical emergencies, such as code situations.

Thus, the purpose of this study was to design, implement, and determine the subjective and objective outcomes of a training curriculum focused on anaphylactoid reactions to iodinated contrast media for radiologic technology personnel. It was hypothesized that the curriculum would provide increased knowledge, comfort, and a teamwork approach and would change the technologists’ practice.

**Methods**

Because this was a quality safety program, institutional review board approval was not required. A diagnostic radiology resident and a board-certified radiologist with previous experience in contrast media lecture and simulation education created a 45-minute PowerPoint (Microsoft) presentation that reviewed:

- How to recognize symptoms of a contrast reaction, with pictures and sample cases.
- The different types of contrast reactions, including typical vital signs seen in moderate and severe reactions.
- Initial treatment steps, such as airway management and oxygen administration route.
- The contents of a contrast reaction box (ie, a box stocked with common medications administered in the event of a contrast reaction).

The sessions also included an anonymous 10-question pretest and a 10-question immediate posttest that had been validated by 2 radiologists not participating in the study implementation. CT technologists on each shift (day and night) viewed the 45-minute presentation and completed an 8-question self-assessment of the training session using a Likert grading scale. The curriculum was repeated 14 months later, with different 10-question pretests and posttests administered.

Statistical analysis included participants’ t test scores to track improvement of mean pretest and posttest scores and assess differences between night-shift and day-shift technologists with a predefined P value of < .05.

**Results**

For the first portion of the study, 17 CT technologists participated in the contrast media training sessions and completed the tests and evaluation forms. A statistically significant difference was seen in pretest and posttest scores (P < .01), with a pretest mean score of 61.3% and a posttest mean score of 100%. All self-assessments were between 1 and 2 on the Likert scale (see Table).
These short-term outcomes are similar to prior research studies that showed immediate improvement of resident knowledge with didactic, simulation, or computer-based curricula about contrast media.\(^7,16-18\)

However, the lower mean pretest scores 14 months later indicate that without frequent repetition of a curriculum, long-term gains do not occur. A recent study by Trout et al similarly demonstrated that residents’ scores were no longer significantly improved relative to pretest scores at 9 months.\(^19\) Scores in the immediate postintervention period and at 3 and 6 months were improved but returned to preintervention scores at 9 months. In addition, residents who had undergone the training for 3 consecutive years did not have statistically significantly higher pretest scores than those new to the curriculum. Predictors of knowledge scores also were time relative to the course, experience with a contrast reaction between examinations, and studying between assessments.\(^19\)

Because exposure to a reaction cannot be predicted and studying is an individual decision, it is important to provide, at minimum, semiannual training sessions for all technologists to retain knowledge.

One means of increasing the frequency of training is by including the technologists in the simulation lab training sessions with radiologists and residents. This tactic also prevents monotony of a purely didactic curriculum. Tofil et al have shown improved posttest scores for both residents and technologists after a single simulation lab experience.\(^13\) Thus, combining didactic material and simulation experience throughout the year might be the best solution and would address different learning styles. Random case-based drills throughout the year also would reinforce knowledge.

After the quality improvement project and additional training, CT technologists were added as instructors in the simulation lab training for intravenous catheter insertion and oxygen administration. These skills are part of basic management during a contrast reaction and continue to foster teamwork within a department.

Potential hindrances to the success of a curriculum for radiologic technologists include access to and funding for simulation training, availability of physicians and managers to create and routinely run didactic sessions, and coordination of technologists’ schedules.

Limitations of the study include small sample size, no delayed posttesting, and no inclusion of simulation or...
hands-on training in the curriculum. Including MR and fluoroscopy technologists and nurses would increase the sample size for future research.

Conclusion

A contrast curriculum for residents and technologists offers subjective and objective benefits, and CT and MR technologists should receive regular education about anaphylactoid reactions to contrast media. For optimal success, the curriculum should be repeated at least every 6 months to sustain knowledge and skills. The program easily could be replicated at other institutions with minimal expense. Future work should involve obtaining continuing education credits for the technologists who participate in the program, testing long-term retention, and expanding the program to nursing staff, all radiologic technologists, and managers.

Jonelle M Petscavage-Thomas, MD, MPH, is an assistant professor of radiology at Penn State Hershey Medical Center in Hershey, Pennsylvania. She has worked on several scientific and review papers related to contrast media at her current and former institutions. She can be reached at jthomas5@hmc.psu.edu.

Heather Kaneda, DO, was a radiology resident while this study was being conducted. She is now a mammography fellow at Emory University in Atlanta, Georgia.

Michael A Bruno, MD, FACR, is the chair of the quality and safety committee at Penn State Hershey Medical Center. He is a professor of radiology and practices nuclear medicine.

Reprint requests may be mailed to the American Society of Radiologic Technologists, Communications Department, 15000 Central Ave SE, Albuquerque, NM 87123-3909, or e-mailed to communications@asrt.org.

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References

Peer Review

The Value of Training Technologists for Adverse Reactions to Contrast


Use of Incentive Spirometry in Portable Chest Radiography

Mark F McEntee, PhD
Nariman Houssein, BSc
Dhafir Al-azawi, MD, FRCSI

Purpose The degree of lung inflation seen on a chest radiograph is dependent on the point during the patient’s respiratory cycle at which the radiographer exposes the image receptor. Exposing the image receptor at the exact peak of inflation can be difficult because of the limited time available in which to capture the inspiratory pause. An incentive spirometer can indicate the moment of peak inhalation. This study tested whether images taken with and without an incentive spirometer display different levels of image quality.

Methods This is a paired, prospective, single-blinded study of 30 patients undergoing portable chest radiography. The radiographs were acquired with and without the use of an incentive spirometer. Visual grading analysis was performed using the 1996 European Guidelines on Quality Criteria for Diagnostic Radiographic Images.

Results The mean patient age was 53 years. Sixty images were acquired, 30 with the use of incentive spirometry and 30 without. The most common indication for portable chest radiography was “postlung lobectomy.”

Discussion Scoring on the radiologist’s ability to see the sixth rib, spine, trachea, and cardiac border was not affected significantly by the use of incentive spirometry. Use of an incentive spirometer was associated with significant improvement in ability to see the 10th rib ($P \leq .004$), vascular pattern ($P \leq .001$), retrocardiac lung ($P \leq .013$), and the costophrenic angles ($P \leq .005$).

Conclusion This study introduces a technique to improve the quality of portable chest radiographs. The use of incentive spirometry improved inspiratory depth and image quality for portable chest radiographs.

Portable chest radiography is one of the most frequently performed radiologic examinations, yet it is the examination with the most variation in image quality. The variety of methods used to perform portable chest radiography indicates that no preferred technique exists among radiographers. One particular challenge is the variability of patient condition and positioning. Patients who undergo portable chest radiography might be alert and able to sit up or supine in a semiconscious state.

Difficulties can arise when radiographers explain the breath-hold technique to patients who have a reduced level of consciousness, resulting in a wide variety of inspiration efforts.

An incentive spirometer is a device used to measure lung capacity. The spirometer comprises a mouthpiece breathing tube and an air chamber that contains a ball indicator. The breathing tube is connected to the air chamber with the mouthpiece at the outer end. The indicator is located inside the device to provide a visual reference that helps patients breathe slowly and deeply. Breathing deeply helps open the airway and fill the lungs with air, which can result in a more accurate diagnostic image, particularly for pulmonary changes.

This study sought to determine whether a standardized approach using an incentive spirometer could improve the image quality of portable chest radiography.

Literature Review

In some hospitals, portable chest examinations account for 40% to 50% of all chest radiography performed. The need to improve the quality of portable chest radiographs has long been recognized, but it is a difficult problem to solve because changes in lung volume and pressure during mechanical ventilation substantially alter the appearance of portable chest radiographs.
radiographs, which alters the interpretation of airspace disease and lung length.\textsuperscript{4,5} Changes in the bedside chest radiographs and changes in the patient’s clinical condition are poorly correlated. Olivetti et al reported:

\textit{No significant correlation was demonstrated between pulmonary radiographic changes and patient clinical conditions classified as unchanged, improving and worsening. In contrast, a good correlation (R = 0.65; p < 0.001) was observed between the chest radiographic score of pulmonary changes and the PaO2/FiO2 ratio.}\textsuperscript{6}

PaO2/FiO2 is the ratio of partial pressure arterial oxygen and fraction of inspired oxygen, sometimes called the Carrico index.\textsuperscript{6} Although changes to this parameter could justify bedside chest radiographs, this exam “appears rather useless when PaO2/FiO2 ratio is unchanged.”\textsuperscript{6} This lack of correlation is caused by several technical (nonphysiologic) factors that affect the appearance of the portable chest radiograph, primarily ventilatory parameters.

The degree of inflation and the pressure in the lungs at the instant the chest radiograph is acquired depend completely on when the radiographer exposes the image receptor during the maximum inflationary period of the respiratory cycle. Exposing the radiograph at the exact peak of inflation can be difficult because of the brevity of the inspiratory pause, especially in seriously ill patients who require complex ventilatory modes, or in pediatric patients who typically have rapid respiratory rates and small tidal volumes. Motion artifact and submaximal inflation are particularly problematic in patients on ventilators who often require frequent chest radiography\textsuperscript{7} and in whom the peak inspiration can be determined with a spirometer.

The positive end-expiratory pressure (PEEP) improves oxygenation in patients with acute respiratory failure. PEEP usually is generated by a pressure-sensitive valve that elevates intrapulmonary pressure at the end of expiration, thus increasing the end-expiratory lung volume. In 1979 Zimmerman et al found that increases in tidal volume or the addition of PEEP to the ventilation parameters produced an apparent reduction of infiltrates on the chest radiograph.\textsuperscript{8}

More recently, studies have shown that chest radiographs acquired during pressure-supported breaths were interpreted as having worse disease compared with interpretations of images acquired during synchronized intermittent mandatory ventilation breaths. These studies confirmed the value of synchronizing the radiography exposure with the inspiratory pause in ventilated patients.\textsuperscript{6,8} No previous studies have been conducted to synchronize radiographic exposure with the inspiratory pause in nonventilated patients requiring portable chest radiography.

\section*{Methods}

This research was approved by the University College Dublin School of Medicine and Medical Science Ethics Committee and by St James’s Hospital Research Ethics Committee. The study was conducted on 30 patients from a 900-bed tertiary academic hospital who were recruited between May 1 and June 1, 2009. In this experiment, the incentive spirometer was used to give the patient a visual reference for breathing and help indicate to the radiographer when the inflationary maximum level had been reached. Patient images were acquired with and without an incentive spirometer.

Patients for whom referring physicians requested portable chest radiography as part of their diagnostic workup were selected from general medical and surgical wards, including orthopedic, respiratory, and cardiac units. Participants included nonventilated men and women aged 18 to 65 years who could sign the consent form and physically use the spirometer. Patients in high-dependency units, who had recently undergone cardiac surgery, who had rib fractures, or who were ventilated were excluded.

Images were acquired while the patient was in full inspiration, first with radiographer instructions only and then with use of the incentive spirometer. Researchers recorded demographics such as name, sex, age, medical diagnosis, and indication for the portable chest radiograph, along with technical factors such as kilovoltage peak (kVp), milliamperesecond (mAs), source-to-image distance, and x-ray tube angulations.

\section*{Incentive Spirometer Technique}

The incentive spirometer’s mouthpiece is mounted on a 50-cm-long tube. It is a sterile device, and the encasing cover is sealed when the facility receives it from the manufacturer. The incentive spirometer used
in the study contained 3 balls. During the assessment, 2 balls were obscured by opaque adhesive tape to avoid confusion for patients (see Figure 1). Each patient was provided a new sterile incentive spirometer. In accordance with American Association for Respiratory Care guidelines, the tubing and mouthpiece sections of the spirometer were for single use only and were discarded after each patient’s examination was complete. The element of the spirometer containing the plastic ball was used by the same patient several times and discarded after the study’s completion. The radiographer performing the study was instructed on the use of the incentive spirometer and received an instruction sheet that included visual cues for instructing patients, along with when to acquire the image (see Box).

Patients underwent informed consent and were instructed regarding the use of the incentive spirometer. The nurse in charge of each patient, along with members of the patient’s medical and surgical teams, was aware of the patient’s participation in this study. Patients for whom chest radiography was requested first had portable chest radiography without the use of the incentive spirometer. If a follow-up chest radiograph was requested within 2 days, the examination was acquired using the incentive spirometer.

The incentive spirometer was placed in an upright position, supported by its own base, on a table or bedside locker and was visible to the patient and radiographer. Neither the patient nor the radiographer held the spirometer, and care was taken to ensure that it did not obscure any anatomy or produce image artifacts. The radiographer positioned each patient to sit as straight and erect as possible in the bed. The open end of the tubing was attached to the bottom of the incentive spirometer, and the mouthpiece was attached to the other end of the tubing. The patient should seal his or her lips tightly around the mouthpiece and inhale slowly and deeply through the mouth. This slow, deep breath will raise the ball in the clear chamber of the spirometer.

Before acquiring the radiograph, the patient received a brief explanation and rehearsed the procedure. When the initial chest radiograph (without spirometry) was acquired, patients were instructed to “take a deep breath in, and hold it in.” When the incentive spirometer was used on the second examination, patients were asked to “take a deep breath in, through the incentive spirometer, and hold it in.” When the ball in the incentive spirometer had risen and then dropped again, the radiographer acquired the image because the spirometer ball’s movement and location indicated that the patient had achieved maximal inspiration. Although the peak of inspiration varied from patient to patient, the goal was to achieve the maximum inspiratory effort for each patient.

**Figure 1.** The Triflow incentive spirometer used in the study was modified so only 1 ball of 3 was seen; the other 2 present in the manufacturer design were obscured to prevent misreading.
Image Production Protocol

All images were acquired using a DirectView CR 500 reader (Eastman Kodak Co/Carestream Health Inc) with GP25 Ektascan cassettes (Kodak). Radiographers printed 35 × 43 cm hard copies on film using a Drystar 3000 laser printer (Agfa HealthCare).

Images were excluded from the study if they did not meet technical radiographic acceptance criteria (eg, under- or overexposed images). Images missing relevant anatomy or requiring repeat imaging because of positioning or technical factors also were excluded.

Lordosis can lead to misreading of the number of ribs, increasing the number of ribs anteriorly (9 ribs) and decreasing the number of ribs posteriorly (6 ribs). It also might show anterior rib ends pointing upward and the diaphragm obscuring the lung bases. Furthermore, in lordotic patients, the heart appears larger as a result of increased magnification from a shorter source-to-image distance and increased object-to-image distance of the heart. Therefore, lordotic images also were excluded for the study.

The acceptance criteria for including an image in the study were:

- Eight or 9 posterior ribs seen above the diaphragm.
- Correct central ray angle – 3 posterior ribs should be seen above the clavicle, indicating an unobscured apical region.
- No movement unsharpness.
- Collimation should include the entire lung fields (both lungs from apices to costophrenic angles and air-filled trachea from T1 down) – hilum region lung markings, retrocardiac lung, great vessels, and bony thorax are demonstrated.

A consultant radiologist evaluated all images using visual grading analysis. The radiologist was not aware of the patient’s name, medical condition, or whether incentive spirometry was used. A paired selection technique was used, ensuring that a randomly selected spirometer-produced image was followed by a randomly selected inspiration image. To compare each patient’s images we used a scoring system adapted from the 1996 European Guidelines on Quality Criteria for Diagnostic Radiographic Images. Radiologists marked each of the following criteria on a scale: 0=Poor, 1=Good, 2=Better, 3=Very good, 5=Excellent.

1. Full inspiration (as assessed by the position of the ribs above the diaphragm—either the sixth rib anteriorly or the 10th rib posteriorly).
2. Visually sharp reproduction of:
   - (a) Vascular pattern in the entire lung, particularly the peripheral vessels.
   - (b) The trachea and proximal bronchi.
   - (c) The borders of the heart and aorta.
   - (d) The diaphragm and lateral costophrenic angles.
3. Visualization of:
   - (a) Retrocardiac lung and mediastinum.
   - (b) Spine through the heart shadow.

All images were assessed under controlled standard viewing conditions. A double light-box illuminator was used, and brightness of the viewing box ranged from 1500 cd/m² to 4000 cd/m². Uniformity reference levels varied from 15% to 30%, with 25 lux ambient lighting, normal room temperature, and normal noise within the reporting room.

Statistical Analysis

The collected results were assessed statistically comparing the 2 groups using a 95% confidence interval and a paired student t test. Data was collected manually and placed on an Excel spreadsheet (Microsoft) and processed using SPSS, version 15 (IBM). Patient information was made anonymous, and access to stored data was password protected according to the ethics regulations.

Results

Thirty patients participated in the study, resulting in 60 images, 30 performed with incentive spirometry and 30 without. Patient age ranged from 18 to 65 years, and the mean patient age was 53 years. Fourteen patients were women and 16 were men. The prevailing indication for the portable chest radiograph in the medical and surgical wards was “postlobectomy” (20%); other indications included checking for pleural effusions, pneumothorax, and postinsertion or postremoval of chest drains (10% each); all other requested more non-descript indications such as “check status” and “post-op.”

Exposure Factors

The minimum tube angle used was 52°, and the maximum tube angle was 70° caudally with a mean of 57.9°.
Portable chest radiography is used widely in intensive care settings; however, this study excluded intensive care patients because of the need to have a conscious and cooperative patient to perform the breathing procedure using the incentive spirometer. Portable chest radiography is performed almost daily in intensive care settings; however, this study excluded intensive care patients because of the need to have a conscious and cooperative patient to perform the breathing procedure using the incentive spirometer.

An important factor to consider in assessing our results is that 20% of the portable radiographs requested were for postlobectomy images. This is a higher percentage for this indication than other published literature. Other indications in our study included pneumothorax, pleural effusions, and evaluation of chest drain insertion or removal. These are similar reasons for request as those published in other literature. Portable chest radiography is used widely in intensive care settings; however, this study excluded intensive care patients because of the need to have a conscious and cooperative patient to perform the breathing procedure using the incentive spirometer.

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Use of Incentive Spirometry in Portable Chest Radiography

**Figure 2.** A. More 10th ribs were observed under the diaphragm in the group of images that did not involve incentive spirometry, and more 10th ribs were observed at the costophrenic angle in the incentive spirometry image group. B. Scoring of the quality of 10th rib visualization in the presence and absence of incentive spirometry, with higher scores observed in the incentive spirometry group ($P \leq .004$). Score refers to the number of cumulative points awarded the visualization of that criteria. Abbreviations: CPA, costophrenic angle; CVA, costovertebral angle; MCL, midclavicular line.

**Figure 3.** A. The vascular pattern is clearer and more radiographs were categorized as very good or excellent quality in the incentive spirometry group. B. Similarly higher scores were assigned to the quality of the vascular pattern in the chest radiographs from the incentive spirometry group ($P \leq .001$). Score refers to the number of cumulative points awarded the visualization of that criteria.
Figure 4. A. Better and very good visualization of the costophrenic angle were found in radiographs in which incentive spirometry was used. B. When the quality of the costophrenic angle was scored, the highest scores were given to the incentive spirometer group ($P \leq .005$). Score refers to the number of cumulative points awarded the visualization of that criteria.

Figure 5. A. For the retrocardiac lung visualization criteria, more images were categorized as better, good, and excellent quality in the incentive spirometry group than in the group not using spirometry. B. Higher scores for quality were assigned to chest radiographs of patients using the incentive spirometer ($P \leq .013$). Score refers to the number of cumulative points awarded the visualization of that criteria.
care units to evaluate the lungs of ventilated patients, but it also is required in nonventilated patients.

Standardizing the method to assess the quality of the portable chest radiograph was important to identify differences between groups. In this study we used the 1996 European Guidelines on Quality Criteria for Diagnostic Radiographic Images, which represent largely agreed-upon criteria among radiology departments on international levels for comparing image quality. To avoid examiner bias while collecting the image quality data, the assessor of image quality was not made aware of the origin of the 2 groups of images. The current study tests the value of using incentive spirometry in changing the depth of inspiration during portable chest radiography exposure and whether the use of this device can improve the quality of the image by timing full inspiration with x-ray exposure.

Our results showed a pattern of no statistical advantage in image quality for the use of incentive spirometry beginning with the sixth rib. Results showed improvement, however, in the visualization of the 10th rib. The 10th rib was seen more frequently at the level of the costophrenic angles in the incentive spirometry group compared with the group that used no spirometry, indicating full chest expansion with the help of incentive spirometry. Visualization of the spine, trachea, and the cardiac border did not significantly differ with the introduction of incentive spirometry, but this can be explained by the probability that limited changes can occur in the location and shape of these organs during the respiratory cycle.

One of the most important variables assessed was the radiologist’s ability to see the peripheral vascular pattern. The patient’s use of the incentive spirometer led to a significant improvement in the ability to visualize the vascular pattern, which demonstrates the value of the incentive spirometer in conditions such as pneumothorax, pulmonary edema, and acute respiratory problems, where the distribution of the vascular pattern has diagnostic value.

A similar significant result was found when assessing the appearance of the costophrenic angles, which favored the use of incentive spirometry. These findings indicate the use of incentive spirometry is of value in identifying pleural effusions and other pathologies involving the pleura and the costophrenic angle. The retrocardiac lung shadow appearance also improved with the use of the incentive spirometer, which is important for discovering pathologies in the retrocardiac region of the lung and mediastinum. The overall score analysis demonstrates the value of incentive spirometry as a tool to improve image quality. The incentive spirometer is a simple, inexpensive device available in all hospitals, originally used to improve patient breathing in cases of chest infections and to improve chest expansion following surgical procedures on the abdomen and chest. The incentive spirometer also can be used as a tool to improve portable chest radiography.

Conclusion

No complications resulted from the use of the incentive spirometer. The device is readily available in medical and surgical hospital units. This study provides a unique method of improving the patient’s full inspiration during portable chest radiography using a simple device. The use of an incentive spirometer significantly improved the quality of portable chest radiographs.

Mark F McEntee, PhD, trained as a radiographer at the University of Ulster at Jordanstown, Northern Ireland, and soon moved into academia, completing a doctoral degree in dose optimization and becoming a lecturer for University College Dublin. He was president of the Irish Institute of Radiography and Radiation Therapy and an inaugural member of the Health and Social Care Professionals Council in Ireland. He is a senior lecturer for the University of Sydney, where he is involved in curriculum renewal, teaching, and research. His research interests include human performance and performance errors, particularly in medical imaging interpretation, as well as dose and image quality analysis. His research goals are to improve radiological diagnostic performance. He can be reached at mark.mcentee@sydney.edu.au.

Nariman Houssin, BSc, is a radiographer for St James’s Hospital in Dublin. She graduated from University College Dublin in 2010.

Dhafir Al-azawi, MD, FRCSI, is a fellow of the Royal College of Surgeons in Ireland and surgeon at Our Lady of Lourdes Hospital, Drogheda, Ireland.

Reprint requests may be mailed to the American Society of Radiologic Technologists, Communications Department, 15000 Central Ave NE, Albuquerque, NM 87123-3909, or e-mailed to communications@asrt.org.

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Over the past 40 years, technological advances in the field of medical imaging have provided an avenue for physicians to use noninvasive means to diagnose disease. Medical imaging procedures that use x-rays, magnetic fields, and sound waves allow physicians to evaluate the human body, often saving patients from undergoing costly surgical procedures. Legislators recently have turned their health care cost-cutting focus to diagnostic imaging. This shift in focus could be a result of reports of dramatic increases in the use of diagnostic imaging procedures and increased health care expenditures.

Medical imaging departments always have been one of the most profitable departments within hospitals. Many health care facilities rely on medical imaging services to subsidize other functions that generate little or no revenue. Between 2000 and 2005, medical imaging service expenditures for Medicare patients billed under the physician fee schedule grew more than all other types of services provided by physicians. This increase was due, in part, to technological advances and the ability of medical imaging to replace surgery as a diagnostic tool. From 2001 to 2006, there was a significant increase in medical imaging procedures, with a 3.6% increase in volume for imaging services provided to Medicare patients compared with an increase of 4.1% for all other services combined. The Deficit Reduction Act of 2006 and other more recent cuts in Medicare reimbursement have resulted in dramatic decreases in the use of and payment for medical imaging and radiation oncology services. The growth rate of noninvasive diagnostic imaging services provided to Medicare patients slowed to 1.4% between 2005 and 2008 and flattened for most of the advanced imaging services such as magnetic resonance (MR) imaging, computed tomography (CT), and positron emission tomography (PET).

After completing this article, the reader should be able to:
- Discuss how and when Medicare and Medicaid were established and how they work.
- Understand who is eligible for Medicare and Medicaid.
- Explain the provisions health care facilities must abide by to obtain payment for services provided to Medicare beneficiaries.
- Understand how recent changes in Medicare reimbursement rates affect a medical imaging or radiation therapy department’s bottom line.
- Recognize and understand the terminology used to explain the Medicare system.
tomography (CT), nuclear medicine, and ultrasonography. The amount Medicare paid for all services grew 31% from 2000 to 2005, but imaging service costs grew 61%, with CT, MR, and nuclear medicine growing the fastest. This growth resulted in an increase in dollars spent by Medicare for imaging services from $6.4 billion in 2000 to $12.3 billion in 2006. Changes in payment systems after 2006 have resulted in decreased expenditures for imaging services as evidenced by total expenditures of $10.9 billion in 2010.

Medicare reimbursement for medical imaging procedures was cut 8 times between 2005 and 2011. Beneficiary claims for imaging services declined in the years 2009 to 2011, with CT, MR, and nuclear medicine showing an approximately 27.6% decrease compared to a 21.3% overall increase in Medicare spending for nonimaging services in the same period. Even with the decline in use and reimbursement rates in recent years, imaging services still account for a significant amount of health care expenditures for Medicare patients. In 2011, Medicare expenditures for imaging services were estimated at $557.8 billion and accounted for 22% of the $2.7 trillion total expenditure for health care services provided to Medicare patients.

Considering the country’s attention toward cutting the cost of Medicare, medical imaging continues to be an area that legislators have focused on for reducing expenditures, which ultimately affects the amount of money available in health care facilities to provide these services and to pay the personnel who perform them. These cuts mean radiologic science professionals need to understand how the Medicare program works, the provisions health care facilities must abide by to obtain payment for services provided to Medicare beneficiaries, and how recent changes in Medicare reimbursement rates affect a medical imaging or radiation therapy department’s bottom line.

**History of Medicaid and Medicare**

Medicaid and Medicare were enacted by Congress in 1965 and implemented on July 1, 1966, through amendments to the Social Security Act. Both Medicaid and Medicare are governmental health insurance programs that provide health insurance at a level equal to that offered by employers. It was estimated that in 2010, 95 million people in the United States, or 31% of the population, were covered by government health insurance. Approximately 44.3 million Americans received Medicare coverage in 2010, and 48.6 million received Medicaid coverage that year.

**Medicaid**

Title XIX of the Social Security Act established Medicaid, which was enacted in 1965 as a state program to help low-income or low-resource individuals and families pay for medical care. Medicaid was not available in all 50 states until 1982. Medicaid funding comes from both federal and state governmental sources. The Centers for Medicare & Medicaid Services (CMS) monitor each state’s program and determine the state’s eligibility for funding. States that abide by federal statutes, regulations, and guidelines are eligible to receive federal funding for the state’s Medicaid program. Each state determines the financial and employment eligibility requirements for participation, the amount and type of assistance provided, and the services covered, so these aspects vary from state to state. The federal government requires states to offer minimum basic services in order to receive matching federal funds. Benefits the state must offer include:

- Inpatient and outpatient hospital services.
- Physician services.
- Laboratory and x-ray services.
- Family planning services.
- Care by midlevel providers.
- Transportation to services.
- Tobacco cessation services.
- Nursing facility services.
- Screening, diagnostic, and treatment services for health, vision, dental, and hearing for individuals younger than 21 years of age.

Federal statutes require states to offer Medicaid to specific groups such as pregnant women, children, and individuals with disabilities. Many states offer services above the level mandated by the federal government, especially services for children. Low-income people who are elderly also access Medicaid for help in paying for premiums, copays, prescriptions, and long-term care. Beneficiaries are required to pay a deductible for Part A services and a premium and deductible and copays for Parts B, C, and D coverage and services. No dental, vision, or long-term care options are available.
with Medicare. Medicaid will pay all or part of the Part B premium for those who qualify, who then also can apply for additional prescription drug and long-term care assistance. Most elderly people obtain secondary insurance or use Medicaid for assistance with coverage for these services.14

The Patient Protection and Affordable Care Act (ACA), which is scheduled to go into effect January 1, 2014, requires states to establish a minimum income eligibility level for individuals aged younger than 65 years and those who earn below 133% of the federal poverty level.13 See Box 1 for a list of common acronyms.

**How Medicaid Is Funded**

The amount of federal funding provided to state Medicaid programs is based on the Federal Medical Assistance Percentages rates. These percentages are reviewed and revised annually by the Social Security Administration.15,16 The federal government contributes between 50% and 75% of a state’s program expenditures based on criteria such as per capita income.16 Each state determines how state funding is acquired, and funding may come from sources such as state payroll taxes and legislative appropriations. The CMS verifies that state funding meets federal requirements before authorizing federal funding.16

Each state determines how services are paid. More than 70% of the states pay under a contract system in which payment rates are negotiated with networks and providers. Other states use a fee-for-service model, with rates based on cost-to-provide services, the rate that private insurance organizations pay for services, and the rate that Medicare pays for the services. Payment rates are based on factors such as the Medicare Economic Index, which is a calculation based on inflation; economic growth rate in the United States; growth in number of beneficiaries and changes in regulations; and other state-based factors that influence inflation rates within the state.16

**Patient Protection and Affordable Care Act**

The primary purpose of the ACA is to decrease the number of Americans who do not have health insurance. The Medicaid program is expected to bear the biggest burden for the implementation of the ACA; its implementation is expected to add 21 million people to the Medicaid program by the year 2022. This increase translates into an estimated $76 billion increase in state Medicaid expenses and $952 billion increase in federal Medicaid expenses between 2013 and 2022.17

**Medicare**

When Medicare was enacted, more than half of Americans older than 65 years of age had little or no health insurance coverage. Medicare was structured to provide no-cost health insurance equal to that of typical employer-provided health insurance for individuals who had reached retirement.1 More than 19 million Americans enrolled in Medicare when this component of the Social Security Act took effect on July 1, 1966. President Harry Truman was the first enrollee.18 In 1972, eligibility to participate in Medicare was extended to include individuals younger than 64 who have long-term disabilities.18

In 1966, Medicare was set up as a 2-tiered system: Part A offered benefits for inpatient hospital services, and Part B offered supplemental insurance for other health care services. Services covered under Part A included inpatient hospital services, skilled-nursing facility services, and hospice care was added to Part A in 1983. Under Part A, the hospital was paid an amount that Medicare determined to be a reasonable cost for treating the patient, regardless of the actual charges issued by the hospital.
Individuals covered by Part A were responsible for paying only a deductible equivalent to the average cost of 1 day’s hospital stay for the first 60 days of hospital care. Between 61 and 91 days, the beneficiary was responsible for paying a daily fee of one-quarter of the average cost of 1 day’s hospital stay. After 90 days, the individual could choose to dip into his or her lifetime reserve—equal to 60 days’ coverage—and pay a daily fee of one-half of the average cost of 1 day’s hospital stay or pay the entire charge.

In rare circumstances, Medicare requires an enrollee to pay a premium for Part A benefits.19 The annual deductible for Medicare in 1966 was $40 per year; in 2013 it was $1184 per year.18,19

Under Part B, Medicare covered nonhospital charges such as:

- Physician office visits.
- Laboratory, radiology, and therapy services.
- Outpatient procedures.
- Home medical equipment.

These services were, and still are, paid based on Medicare’s reasonable-cost basis. Medicare Part B is a voluntary plan, and the individual is responsible for an annual deductible and coinsurance. In 2003, the Medicare Prescription Drug, Improvement, and Modernization Act, also known as the Medicare Modernization Act (MMA), authorized a tiered premium system based on income. Table 1 compares the monthly premium, annual deductible, and per-service copay for Medicare Part B in 1966 vs 2013.18,19

Medicare Plan C, also known as Medicare Advantage, was enacted in 2003 to allow private insurance companies to cover the benefits offered by Medicare Plans A and B. Plan C allows eligible participants to choose the carrier for their health care benefits—either the federal government or a private insurance company.20

Section 101 of the MMA of 2003 amended Title XVIII of the Social Security Act by implementing Medicare Part D as a voluntary prescription drug benefit program. Medicare Part D, implemented in 2006, is only available to people enrolled in Medicare Parts A or B and requires annual enrollment.21,22

How Medicare Is Funded

With the original enactment of Medicare in 1966, a federal payroll tax—funded by employers, employees, and self-employed individuals—was authorized to fund Part A of the Medicare plan, and this plan was offered to all American citizens aged older than 65 years at no cost. The 1966 payroll tax was established as 0.35% on wages, up to a maximum of $6600 annually. For $3 a month, Medicare Part B was available to all U.S. citizens and to legal aliens who had lived in the United States for more than 5 years. At the time of enactment, the federal government estimated the actual cost to provide services under Plan B at approximately $72 per year, so the individual enrollee’s premium covered half of the actual cost to provide the services, and the federal government funded the other half.8,18

In 2013, the Medicare payroll tax was 2.9%, with half being paid by the individual through payroll deductions and half by the employer. Self-employed individuals pay the full 2.9%. No wage limits are in place today. In addition, beginning in 2013, individuals were assessed an additional Medicare tax of approximately 3.8% on investment income if their modified adjusted gross income exceeded $250 000 for married couples filing jointly, $200 000 for single people or heads of household, or $125 000 for married couples filing separately.23

Over the past 40 years, the services provided under Medicare have evolved to ensure that elderly people in America have the same access to and level of care provided by “standard” health insurance policies.3 Unfortunately, funding for Medicare has not kept up with costs to administer the program, and the system as originally envisioned is no longer sustainable.

How Providers Qualify to Receive Medicare Payments

Health care providers are required to meet certain conditions to maintain eligibility to submit and receive payment for services provided to Medicare beneficiaries.

Table 1

<table>
<thead>
<tr>
<th>Medicare Part B Cost Comparison</th>
<th>1966</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premium per month</td>
<td>$3</td>
<td>$104</td>
</tr>
<tr>
<td>Deductible per year</td>
<td>$50</td>
<td>$147</td>
</tr>
<tr>
<td>Copay per service</td>
<td>20%</td>
<td>20%</td>
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</table>
These conditions for participation are met through an accreditation process or participation in a quality reporting program.

**Accreditation**

Accreditation is a process used to monitor and control health care facilities and providers and to ensure that these entities and individuals meet or exceed minimum standards and qualifications. Many accreditation programs are available in the health care arena, with most of them focused on specific services provided by health care facilities and providers. Federally mandated accreditation programs outline the qualifications health care facilities and providers must meet in order to bill for and receive payment for services to Medicare beneficiaries. These programs typically fall into 2 categories: hospital accreditation and outpatient or ambulatory care facility accreditation.

**Hospital Accreditation**

Hospital accreditation was part of the 1965 Medicare program. The original law recognized the authority of the Joint Commission, formerly known as the Joint Commission on Accreditation of Healthcare Organizations, to accredit hospitals and accepted this accreditation as compliance with certification standards for participation in the Medicare program. The Department of Health, Education, and Welfare administered Medicare but did not have access to Joint Commission accreditation actions or means for validating the program.

The law also prohibited the federal government from imposing additional requirements to Joint Commission–accredited facilities. Amendments to the Social Security Act passed in 1972 permitted the Department of Health, Education, and Welfare to impose standards more stringent than the Joint Commission’s on hospitals and allowed a mechanism for state agencies to validate Joint Commission accreditation actions. This action provided the gateway for the current relationship between the Joint Commission and Medicare.24

CMS contracts with the Joint Commission and some state accrediting agencies to administer hospital accreditation programs for assurance that the hospitals are in compliance with conditions of participation in the Medicare program. For hospitals to qualify to receive Medicare payments, they must be accredited either by the Joint Commission or by an authorized state accrediting agency.25

**Outpatient Facility Accreditation**

The Medicare Improvements for Patients and Providers Act of 2008 (MIPPA) amended the Social Security Act to require accreditation of physicians, nonphysician practitioners, and independent diagnostic testing facilities that provide the technical component of MR, CT, and positron emission tomography–computed tomography (PET-CT) procedures after January 1, 2012. The law also allows the Secretary of Health and Human Services to include imaging services other than radiography, ultrasonography, and fluoroscopy, which are excluded, and mammography, which requires accreditation through the Mammography Quality Standards Act. MIPPA regulations authorize the American College of Radiologists, the Intersocietal Accreditation Commission, and the Joint Commission to accredit practices and facilities that provide advanced imaging services.26 The recognized agencies each establish standards that an accredited facility must abide by to attain and maintain accreditation and to submit and receive payment for services provided to Medicare beneficiaries.

**Quality Reporting**

The CMS established 3 goals for quality initiatives: better health, better health care, and lower costs. The CMS takes the stance that quality measurement and reporting will improve the quality of the services consumers receive because it encourages providers and health care facilities to become more aware of the quality of the services they provide and to implement processes to improve the quality of the services measured.27

The quality reporting programs implemented by CMS align payment incentives to quality measures and include all levels of service covered by Medicare. In addition to the general quality reporting programs, CMS has additional programs for inpatient and ambulatory surgical centers that affect either a percent of payment or offer incentives for participation in the programs.28 All of the quality programs and measures are reviewed and updated annually.
Hospital Inpatient Quality Reporting Program

Included in the 2003 MMA, with additional requirements added as part of the 2005 Deficit Reduction Act, the Hospital Inpatient Quality Reporting Program provides consumers with information about the quality of care provided by hospitals. The program’s intent is to ensure quality through public disclosure and accountability. It requires hospitals to submit data on specific measures for common diseases or health care services such as acute myocardial infarction, heart failure, pneumonia, immunizations, emergency department services, mortality and readmission rates, and patient satisfaction. The information hospitals submit is available to the general public online (www.medicare.gov/hospitalcompare). Currently, CMS reduces payment rates by 2% for all Medicare services provided by hospitals that do not participate in the Hospital Inpatient Quality Reporting Program.

Hospital Outpatient Quality Reporting Program

The Hospital Outpatient Quality Reporting Program, implemented in 2011, affected payments for services provided to Medicare beneficiaries beginning in 2012. To determine eligibility for payment in 2014, hospitals were required to submit quality measure information for patients who were treated in 2012 for acute myocardial infarction, chest pain, emergency department throughput, pain management, stroke, outpatient surgery, imaging efficiency, and other facility measures. Hospitals must report prior-year standardized measures data to receive the full outpatient prospective payment system (OPPS) rate for the following fiscal year. The full payment is available to hospitals that submit accurate and complete data for all the outpatient measures. Currently, payment is tied only to reporting of quality data, not to performance or minimum standards of quality in these measures. Box 2 lists the specific quality measures that hospital-based outpatient radiology departments were required to report in 2013 to qualify to receive full payment for services provided to Medicare beneficiaries in 2014.

Physician Quality Reporting System

Several federal mandates shape the Physician Quality Reporting System (PQRS): The Tax Relief and Health Care Act of 2006 authorized the Physician Quality Reporting Initiative, MIPPA authorized incentive payments for providers who meet requirements through the PQRS through 2010, and the ACA authorized incentive payments for participants in the PQRS through 2014, with penalties beginning in 2015 for providers who do not report quality measures. Physicians can participate in the program as individuals or as members of a group practice. Other allied health professionals required to participate in the PQRS include physical, occupational, and speech language therapists, audiologists, nurse practitioners, and physician assistants.

Box 2

**Hospital-Based Outpatient Radiology Department Quality Measures**

- MR imaging lumbar spine for low back pain – reports the percent of MR imaging of lumbar spine studies performed on Medicare beneficiaries with a diagnosis of low back pain and for which the patient has no evidence of conservative therapy prior to performance of the MR imaging.
- Mammography follow-up rates – reports the percent of Medicare patients with screening studies who also have a diagnostic ultrasonography or MR follow-up examination within 45 days of a screening mammogram.
- Abdomen CT use of intravenous contrast material – reports the ratio of CT abdominal scans performed on Medicare patients with and without intravenous contrast compared to all CT abdomen studies performed on Medicare patients.
- Thorax CT use of intravenous contrast material – reports the ratio of CT chest procedures performed on Medicare patients with and without contrast compared to all CT chest studies performed on Medicare patients.
- Cardiac imaging for preoperative risk assessment for noncardiac low-risk surgery – reports the percent of stress echo, single-photon emission CT myocardial perfusion imaging, or stress MR imaging studies performed on Medicare patients at a hospital outpatient facility 30 days prior to an outpatient, low-risk noncardiac surgery performed anywhere on the same Medicare patients.
- Simultaneous use of brain CT and sinus CT – reports the percent of brain CT and sinus CT performed on the same Medicare patient on the same day by the same facility.
Quality measures for physicians include documentation of:

- Patient and family engagement, such as plan of care for falls or pain management.
- Patient safety, such as timely administration of antibiotics prior to surgical procedures, medication reconciliation, and documenting exposure time for procedures using fluoroscopy.
- Care coordination, such as a reminder system for screening mammography, surveillance of abdominal aortic aneurysm repair after surgery, and biopsy result follow-up.
- Clinical processes/effectiveness for disease management, such as effective control of high blood pressure and aspirin use by patients with ischemic vascular disease.
- Effective use of health care resources, such as overuse of bone scans for staging low-risk prostate cancer.
- Population and public health services, such as preventive screening for tobacco use and high blood pressure.

**How Bills for Services Are Processed**

Private insurers have processed Medicare claims since the program was enacted. This system for processing payments was established to alleviate concerns from health care organizations that the federal government could interfere with providers’ abilities to practice medicine if a government agency were reviewing and processing claims. In response to these concerns, Congress included provisions for private insurance companies to contract with the federal government to review and process Medicare claims.

**Medicare Administrative Contractors**

The system for reviewing and processing Medicare claims was established with 2 types of contractors. Fiscal intermediaries process and pay Medicare Part A claims, and health insurance carriers process and pay Medicare Part B claims. Part B contracts were awarded by geographical region so the same carrier processed all the claims in a specific region. The role of contractors evolved from a bill payment service to more autonomous organizations that developed coverage policy and provided education to medical providers. Both Part A fiscal intermediaries and Part B authorized carriers were provided the authority to determine the appropriate payment amounts by applying Medicare coverage rules and setting controls to mitigate fraud and abuse. This structure remained in place until 2002 when the MMA was passed.

The MMA included provisions for reforming Medicare contracts to address issues that had evolved with the system since 1965. The statutes mandated that the 2 contractor systems merge, with carriers within the resulting system referred to as Medicare Administrative Contractors (MACs). The MMA also provided the federal government and contractors more options for the contracts and mandatory review for contract renewals at 5-year intervals. Prior to 2003, health care provider associations nominated organizations to be fiscal intermediaries, and CMS selected from the list of nominated carriers. With enactment of MMA, selection of MACs occurs through a competitive bidding process.

Currently, the United States is divided into 15 regions, with each region having 3 contracted MACs: 1 to process Part A and B payments, 1 to process durable medical equipment payments, and 1 to process home health care payments.

**How Services Are Billed**

The CMS uses 4 systems to pay for services provided to Medicare beneficiaries. The Inpatient Prospective Payment System is used by hospitals—other than critical access hospitals—to bill for inpatient (Part A) services provided to Medicare beneficiaries. Noncritical access hospitals bill for outpatient (Part B) services provided by the hospital. Providers use the physician fee schedule to bill for physician services provided to all Part A and B beneficiaries and services provided to Part B beneficiaries at ambulatory care facilities. Hospitals designated as critical access hospitals have a billing system that pays 101% of reasonable costs for services provided to Part A and B beneficiaries (see Box 3). In 1983, the Health Care Finance Association implemented a new reimbursement system for Medicare claims for inpatient services. Prior to this, the payment system was a retrospective, cost-based payment system that allowed health care facilities to receive payment from
Medicare Reimbursement: What R.T.s Should Know

Box 3

**Payment Scenario Examples**

A Medicare patient wakes up one morning with shortness of breath and fever and decides to seek medical care. Depending on the type of facility the patient accesses for care and the final diagnosis, payment for diagnostic tests and treatment will differ. To compare the payment differences, we will assume the patient receives a chest radiograph regardless of facility and final diagnosis and has already met annual deductibles for Medicare Parts A and B.

If the patient accesses care at a physician’s office and this office has capabilities to perform a chest radiograph, the Medicare Physician Fee Schedule (MPFS) is used to bill for the radiographic procedure. The patient is responsible to pay the $6.63 copayment, and Medicare reimburses the physician’s practice $33.14 for performing and reading the radiograph, regardless of the amount the physician’s office actually bills for the imaging.

If the physician’s office does not have capabilities to perform the examination and sends the patient to the hospital for an outpatient procedure, the Hospital Outpatient Prospective Payment System is used to bill for the radiograph. The patient is responsible to pay the copayment of $11.25, and Medicare reimburses the hospital $45.95 for performing the procedure and the radiologist $10.28 for interpreting the radiograph, regardless of the amount the hospital and the radiologist actually bill for the examination.

If the patient accesses care at the emergency department, receives a chest radiograph and subsequently is admitted as an inpatient for 5 days for treatment of pneumonia and pleurisy without complicating conditions, the Healthcare Common Procedure Coding System diagnosis-related groups (DRGs) are used to bill for treatment of the patient’s pneumonia, and MPFS is used to bill for the interpretation of the radiograph. The patient is responsible to pay the inpatient copayment of $0 (because the patient already met the deductible), and Medicare reimburses the hospital $3984.08 for treating the patient’s pneumonia, regardless of how much the hospital bills for diagnosis and treatment of the infection. Because this payment is for all services provided to diagnose and treat the patient’s condition, no separate payment is made to the hospital for the radiograph. The radiologist will be reimbursed $10.28 for interpreting the radiograph.

Medicare for all services rendered to patients covered by Medicare Part A. On September 30, 1983, the Health Care Finance Association implemented a prospective payment system based on diagnosis-related groups (DRGs). This system categorized a patient’s diagnosis into a DRG. Each DRG had a payment amount assigned based on the national average cost to treat that specific diagnosis or disease. With a diagnosis-based payment system, a health care facility is reimbursed according to a predetermined amount that is dependent upon the patient’s diagnosis and appropriateness of the services provided, which was determined prior to payment being made. Congress mandated the change from a retrospective cost-based system to the prospective payment system based on DRGs in an effort to contain health care expenditures and to use Medicare funds more efficiently. This system is still in use today.

Radiology services provided to inpatients are considered part of the treatment for the diagnosis, so the hospital does not bill or receive payment for these services in addition to the DRG payment. Inpatient services are billed under the Healthcare Common Procedure Coding System of Part A. Hospitals cannot bill separately for the technical component of radiology or radiation oncology services provided to inpatients, but physicians can be billed separately for the services they provide to inpatient Medicare beneficiaries.

**Outpatient Services Provided by a Hospital**

The Balanced Budget Act of 1997 authorized implementation of a Hospital Outpatient Prospective Payment System (HOPPS) and, after several years of refinement, HOPPS became effective for all outpatient services provided by a hospital on or after August 1, 2000. HOPPS reimbursement calculations are based on Ambulatory Payment Classification (APC) groups. The APC system uses the relative value unit (RVU) to determine a fair and equitable payment for the services provided by a health care facility. CMS determines how many resources are typically allocated to provide a specific treatment or test. It then weighs the resources allocated to provide the treatment against...
Common supplies used for radiology that are no longer paid outside of the APC system include:\(^{43,44}\):
- Guidance services such as use of ultrasonography in interventional labs to locate arteries.
- Image processing.
- Diagnostic radiopharmaceuticals.
- Contrast agents.
- Observation time.
- Implantable medical devices.
- Routine supplies such as needles and syringes.

**Outpatient Services Not Provided by a Hospital**

Medicare Part B payment systems for services provided by physicians and nonhospital facilities have changed dramatically in the past 2 decades. Initially, the Part B payment rate was calculated based on the annual actual allowable charges in the prior year. This was changed in 1984 to limit the annual increase. In 1992, the resource-based relative value scale physician fee schedule was implemented. This system calculated payment rates based on the estimated physician time and other resources needed to provide a specific service.\(^8\) Outpatient radiology services not provided in or by a hospital are billed under Medicare Part B, and the rates are based on the Current Procedural Terminology-4 portion of Healthcare Common Procedure Coding System codes. This billing system is referred to as the Medicare Physician Fee Schedule (MPFS).\(^40\)

The MPFS for each procedure has 3 components: physician, technical, and global. The physician component is the payment for the independent licensed practitioner’s services. Payments for services provided by a midlevel provider are calculated as a percentage of the total physician component for the service. The technical component is the payment for all other resources used to provide the service, such as the medical equipment and nonprovider staff time. The global component includes a payment for both the physician and technical components and usually is for services provided by a private practice or independent diagnostic testing facility, or when the hospital employs the physicians.\(^{40}\) The MPFS rates are based on RVU, conversion factor, and geographic practice cost indices, and there are 3 types of RVUs:\(^{47}\):
- Work RVU – estimates time and intensity to provide the services, accounts for about 50% of the payment rate, and is reviewed at least once every 5 years.
practice expense RVU – estimates the costs of maintaining a practice.
- Malpractice RVU – estimates the expense of carrying insurance for malpractice.

Until 1994, the practice and malpractice expense RVUs were calculated separately and based on average allowable charges. The practice expense RVU is based on estimated expenses for managing an office practice. These expenses include personnel wages, rent, and office furniture.\(^2\) The conversion factor is reviewed and updated annually based on comparison of actual expenditures to the sustainable growth rate. This annual adjustment is called the Medicare Economic Index. The sustainable growth rate calculation is derived from medical inflation, projected growth in the U.S. economy, projected growth in the number of Medicare beneficiaries, and changes in statutes and regulations. The geographic practice cost indices account for geographic variations in costs of practicing medicine in different parts of the country and are updated every 3 years.\(^2\)

### Effect of Recent Regulatory Changes

#### OPPS and MPFS Reimbursement Disparity

The implementation of OPPS in the early 2000s resulted in a flattening of rate increases for outpatient services provided by hospitals (see Table 2).\(^{37,48,49}\) Unfortunately, these changes also resulted in disparity in reimbursement rates between OPPS and MPFS, with reimbursement rates much higher for procedures performed outside of a hospital setting (see Table 3).\(^{46-51}\) As a result of this disparity, hospitals and physicians began to open independent diagnostic testing centers to take advantage of the higher reimbursement rates for procedures billed through the MPFS. Between 2000 and 2005, medical imaging service expenditures for Medicare patients billed under MPFS grew more than all other types of services provided by physicians.\(^3\) There was a significant increase in use of and payment for medical imaging procedures, with a 3.6% increase in volume for imaging services provided to Medicare patients from 2001 to 2006, compared with an increase of 4.1% for all other services combined.\(^1\)

The CMS recognized these increases in volume and expenditures for diagnostic imaging services, and Congress addressed the issue. The Deficit Reduction Act of 2005 enacted a cap on the MPFS rates for the technical component of imaging procedures to be no more than the rate paid through OPPS. In 2007, the method CMS used to calculate the RVUs for services was revised to include direct and indirect practice expense RVUs, using the same calculation for determining rates for services that do and do not involve a physician, and using up-to-date practice cost data to estimate indirect physician expense RVUs. The phase-in for these changes to RVU rate calculations was completed in 2010.\(^2\) Table 4 shows the result of RVU rate calculation changes on MPFS.\(^{34,50,51}\)

#### Use Rate Changes

The CMS uses a cost-per-minute use over the life expectancy of imaging equipment, including capital and maintenance costs, as the basis for determining practice costs. The CMS also factors in the percentage of time the equipment is available to perform procedures in a 50-hour workweek. This factor is referred to as the utilization rate. In 2008, the utilization rate was 50%; in 2010, it was changed to 75% for the technical component of imaging equipment used by physicians, physician practices, and independent diagnostic testing facilities—those who use MPFS to bill for these services.\(^2\) Through 2013, the RVU was calculated assuming patients are

### Table 2

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2003 ($)</th>
<th>2008 ($)</th>
<th>2013 ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70470 – CT head/brain w/o &amp; w/dye</td>
<td>295.93</td>
<td>325.64</td>
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<tr>
<td>71020 – Chest x-ray</td>
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<td>73218 – MRI upper extremity w/o dye</td>
<td>364.58</td>
<td>343.52</td>
<td>338.49</td>
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<td>76856 – US exam, pelvic, complete</td>
<td>88.42</td>
<td>96.14</td>
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<td>78315 – Bone imaging, 3 phase</td>
<td>235.60</td>
<td>242.29</td>
<td>261.68</td>
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<tr>
<td>77418 – Radiation Tx delivery, IMRT</td>
<td>400.00</td>
<td>347.65</td>
<td>483.70</td>
</tr>
</tbody>
</table>

Abbreviations: CT, computed tomography; IMRT, intensity-modulated radiation therapy; MRI, magnetic resonance imaging; Tx, treatment; US, ultrasound; w/ , with; w/o, without.

* Short descriptors as identified by the Centers for Medicare & Medicaid Services.
being imaged 37.5 hours in each 50-hour workweek. Part of the fiscal cliff deal made on January 1, 2013, increased the utilization rate to 90%, meaning for services billed after January 1, 2014, the RVU calculation now assumes imaging equipment would be imaging patients 45 hours per 50-hour workweek. Higher utilization rates lower the technical component calculation because the cost of the equipment is allocated over a higher number of hours of use. The 90% utilization rate only affects equipment that cost more than $1 million. With a utilization rate of 90%, it is estimated that most CT and MR procedures will see a decrease in reimbursement rates of 10% to 20% beginning in 2014.53

### Multiple Procedure Payment Reduction

Multiple Procedure Payment Reduction (MPPR) on the technical components of certain diagnostic imaging procedures was implemented as part of the ACA and became effective January 1, 2011. The change required a reduction in the technical component payment for certain imaging services, primarily CT, MR, and ultrasound, on the same patient, during the same session, 36,50,51

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2003 MPFS ($)</th>
<th>2003 OPPS ($)</th>
<th>2013 MPFS ($)</th>
<th>2013 OPPS ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70470 – CT head/brain w/o &amp; w/dye</td>
<td>55.58</td>
<td>218.18</td>
<td>273.77</td>
<td>352.69</td>
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<td>71020 – Chest x-ray</td>
<td>9.49</td>
<td>19.26</td>
<td>28.74</td>
<td>47.49</td>
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<tr>
<td>73218 – MRI upper extremity w/o dye</td>
<td>58.82</td>
<td>343.32</td>
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<tr>
<td>76856 – US exam, pelvic, complete</td>
<td>27.15</td>
<td>43.82</td>
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<td>546.80</td>
<td>285.99</td>
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### Table 3

**Examples of Unadjusted Rate Comparison, MPFS vs OPPS**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2003 MPFS ($)</th>
<th>2003 OPPS ($)</th>
<th>2013 MPFS ($)</th>
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</tr>
<tr>
<td>73218 – MRI upper extremity w/o dye</td>
<td>58.82</td>
<td>343.32</td>
<td>402.14</td>
<td>64.75</td>
</tr>
<tr>
<td>76856 – US exam, pelvic, complete</td>
<td>27.15</td>
<td>43.82</td>
<td>70.97</td>
<td>90.36</td>
</tr>
<tr>
<td>78315 – Bone imaging, 3 phase</td>
<td>44.97</td>
<td>147.53</td>
<td>192.49</td>
<td>242.29</td>
</tr>
<tr>
<td>77418 – Radiation Tx delivery, IMRT</td>
<td>546.80</td>
<td>347.65</td>
<td>825.99</td>
<td>483.70</td>
</tr>
</tbody>
</table>

### Table 4

**Examples of Unadjusted Rate Changes in the Physicians Fee Schedule**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>2003 ($)</th>
<th>2008 ($)</th>
<th>2013 ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70470 – CT head/brain w/o &amp; w/dye</td>
<td>55.58</td>
<td>61.31</td>
<td>43.58</td>
</tr>
<tr>
<td>71020 – Chest x-ray</td>
<td>9.49</td>
<td>10.28</td>
<td>7.49</td>
</tr>
<tr>
<td>73218 – MRI upper extremity w/o dye</td>
<td>58.82</td>
<td>64.75</td>
<td>46.27</td>
</tr>
<tr>
<td>76856 – US exam, pelvic, complete</td>
<td>27.15</td>
<td>33.14</td>
<td>23.68</td>
</tr>
<tr>
<td>78315 – Bone imaging, 3 phase</td>
<td>44.97</td>
<td>49.13</td>
<td>34.25</td>
</tr>
<tr>
<td>77418 – Radiation Tx delivery, IMRT</td>
<td>546.80</td>
<td>546.80</td>
<td>285.99</td>
</tr>
</tbody>
</table>
on the same day by 75% for lesser rate procedures.\textsuperscript{55,56} As of January 1, 2013, technical and physician component reduction applies to physicians in the same group practice who provide services to the same patient, in the same session, on the same day (see Table 5).\textsuperscript{55,56}

**Accountable Care Organizations**

Accountable Care Organizations (ACOs) are part of the Medicare Shared Savings Program created as part of the ACA. Data showed that areas in the United States with lower Medicare cost-per-beneficiary had higher quality care.\textsuperscript{57} The term ACO was developed on the assumption that excessive Medicare expenditures are due to discretionary services that include more frequent hospital stays, specialist referrals, and increased use of diagnostic testing. ACOs intend to provide high-quality care or to improve care while decreasing the cost of providing that care.

The ACO option allows groups of physicians, hospitals, and other health care providers to form partnerships and voluntarily agree to accept responsibility for caring for a defined group of Medicare beneficiaries for a specific amount of money.\textsuperscript{57,58} An ACO is expected to provide optimal care from a patient’s perspective, and the provision of this care has to be operationalized by clinicians, facilities, and patients into plans of care customized to each patient. The plans of care must be evidence-based and managed more efficiently than the care provided by the current health care system. The success of an ACO depends on the ability of the partnership to enable and sustain improved performance across the whole health care system and moves health care into the business-process-management world.\textsuperscript{59}

An ACO contracts with CMS to provide services to a defined group of Medicare beneficiaries. The ACO is required to meet certain quality standards, share data with CMS, and accept payments set by CMS for total care of the patient—not individual services provided to the patient. ACOs do not bill under any current Medicare payment plans, and the ACO receives the payment, not individual providers or facilities.\textsuperscript{59}

Medicare establishes spending targets for ACOs based on the past 3 years’ expenditures for a specific Medicare population and estimates them for the future based on anticipated increases in national Medicare spending. The established ACO spending targets do not include geographic factoring.\textsuperscript{60} The ACO benefits when the group provides high-quality care and improves beneficiary health at a cost lower than CMS expects.\textsuperscript{57,58} If the ACO provides care for a group of beneficiaries at a cost lower than the spending targets, it receives a percentage of the savings and distributes the savings among the partners of the ACO. However, if the cost to provide services to a group of beneficiaries is higher than expected, the ACO is expected to cover the difference. Specific items identified as potential cost savers include reduction in specialty and hospital expenditures; appropriate use of referrals; reducing emergency department visits, admissions, nosocomial infections, and adverse events; and shortened hospital stays.\textsuperscript{57}

### Table 5

<table>
<thead>
<tr>
<th>Procedure*</th>
<th>2008 ($)</th>
<th>2013 ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GC</td>
<td>PC</td>
</tr>
<tr>
<td>70470 – CT head/brain w/o &amp; w/dye</td>
<td>352.69</td>
<td>43.58</td>
</tr>
<tr>
<td>72127 – CT neck spine w/o &amp; w/dye</td>
<td>430.38</td>
<td>43.34</td>
</tr>
<tr>
<td>74177 – CT adb &amp; pelv w/contrast</td>
<td>62.36</td>
<td>178.46</td>
</tr>
<tr>
<td>72193 – CT pelvis w/dye</td>
<td>335.93</td>
<td></td>
</tr>
<tr>
<td>74160 – CT abdomen w/dye</td>
<td>365.25</td>
<td></td>
</tr>
<tr>
<td>Final Total Payment</td>
<td>1484.25</td>
<td></td>
</tr>
</tbody>
</table>

* Short descriptors as identified by the Centers for Medicare & Medicaid Services.

**Abbreviations:** adb, abdomen; CT, computed tomography; GC, global component; PC, physician component; pelv, pelvis; TC, technical component; w/, with; w/o, without.
Conclusion

Technological advances in medical imaging have provided physicians with noninvasive means to diagnose disease. Because medical imaging departments always have been one of the most profitable departments operated within hospitals, many health care facilities rely on medical imaging services to subsidize other functions that generate little or no revenue.

Between 2000 and 2005, medical imaging service expenditures for Medicare patients billed under the physician fee schedule grew more than all other types of services provided by physicians.

The Deficit Reduction Act of 2006 and other more recent cuts in Medicare reimbursement have resulted in dramatic decreases in the use of and payment for medical imaging and radiation oncology services. Medicare reimbursement for medical imaging procedures was cut 8 times between the years 2005 and 2011. Per-beneficiary claims for imaging services declined in the years 2009 to 2011, with CT, MR, and nuclear medicine showing an approximate 27.6% decrease compared to 21.3% overall increase in Medicare spending for nonimaging services in the same period.6,8 The reduction in Medicare reimbursement for medical imaging and radiation therapy procedures has decreased the amount of money available in health care facilities to provide these services and to pay the personnel who perform them.

Liana Watson, DM, R.T.(R)M(S)(BS), RDMS, RV, FASRT, is the chief governance and development officer for the American Society of Radiologic Technologists. She has worked as a radiology administrator and published several articles in Radiologic Technology in the areas of breast imaging, professional development, leadership, and job satisfaction. She extensively researched Medicare reimbursement while in graduate school during the early 2000s. Watson is a former member of the ASRT Foundation Board of Trustees and a 2004 GE Healthcare Management Scholarship recipient.

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References


39. Burda D. What we’ve learned from DRGs. Mod Healthc. 1993;23(40):42-44.


Medicare Reimbursement: What R.T.s Should Know

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*Your answer sheet for this Directed Reading must be received in the ASRT office on or before this date.

Read the preceding Directed Reading and choose the answer that is most correct based on the article.

1. Changes in payment systems after 2006 have resulted in decreased expenditures for imaging services as evidenced by total expenditures of ______ billion in 2010.
   a. $10.9
   b. $12.3
   c. $18.6
   d. $21.2

2. Between 2009 and 2011, beneficiary claims for computed tomography (CT), magnetic resonance (MR) imaging, and nuclear medicine services:
   a. remained the same.
   b. increased by 21.3%.
   c. increased by 31%.
   d. decreased by 27.6%.

3. In 2011 Medicare expenditures for imaging services were estimated to be:
   a. $557.8 billion.
   b. $660.4 billion.
   c. $800.3 billion.
   d. $2.7 trillion.

4. Medicaid and Medicare were enacted by Congress in:
   a. 1962.
   b. 1965.
   c. 1972.
   d. 1986.

5. It was estimated that in 2010, government health insurance covered ______ % of the population in the United States.
   a. 31
   b. 44.3
   c. 48.6
   d. 50
6. For which of the following low-income or low-resource groups does Medicaid provide health care services?
   a. families
   b. individuals
   c. immigrants
   d. 1 and 2

7. The minimum basic Medicaid services states are required to offer in order to receive matching federal funds include:
   a. inpatient and outpatient hospital services.
   b. laboratory and x-ray services.
   c. transportation to services.
   d. 1 and 2

8. The Medicare program that covers inpatient hospital services is:
   a. Part A.
   b. Part B.
   c. Part C.
   d. Part D.

9. The Medicare program that covers nonhospital charges such as physician office visits and outpatient procedures is:
   a. Part A.
   b. Part B.
   c. Part C.
   d. Part D.

10. Medicare is funded by all of the following except:
    a. self-employed individuals.
    b. employees in the United States.
    c. employers in the United States.
    d. private insurance carriers.

11. For hospitals to qualify to receive Medicare payments, they must be accredited by the ______ or an authorized state accrediting agency.
    a. Intersocietal Accreditation Commission
    b. Joint Commission
    c. Centers for Medicare & Medicaid Services (CMS)
    d. National Committee for Quality Assurance

12. The Medicare Improvements for Patients and Providers Act of 2008 (MIPPA) requires accreditation of physicians, nonphysician practitioners, and independent diagnostic testing facilities that provide the technical component of which procedures?
    a. MR
    b. CT
    c. PET-CT
    d. 1 and 2

13. The ______ provides consumers with information about the quality of care provided by hospitals.
    a. Patient Protection and Affordable Care Act (ACA)
    b. MIPPA
    c. Hospital Inpatient Quality Reporting Program
    d. CMS
14. Hospitals that do not participate in the Hospital Inpatient Quality Reporting Program have their Medicare payment rates:
   a. reduced by 4%.
   b. reduced by 2%.
   c. paid at full rate.
   d. increased by 1.5%.

15. The Hospital Outpatient Quality Reporting Program requires hospitals to report in 2013 all of the following quality measures except:
   a. mammography follow-up rates.
   b. use of intravenous contrast materials with thorax CT.
   c. CT head scans performed on emergency department patients presenting with headaches.
   d. MR imaging lumbar spine for low back pain.

16. The United States is divided into 15 regions, and each region has 3 Medicare Administrative Contractors (MACs). MACs process which types of Medicare claims payments?
   1. Part A and Part B
   2. home health care
   3. transportation to services
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

17. Radiology services provided to inpatients are considered part of the treatment for the diagnosis, so the hospital does not bill or receive payment for these services in addition to the diagnosis-related group payment.
   a. true
   b. false

18. The Ambulatory Payment Classification (APC) system uses the relative value unit to determine:
   a. the number of physician visits allowed each patient.
   b. a fair and equitable payment for the services provided by a health care facility.
   c. who can be admitted to the hospital.
   d. the number of diagnostic tests allowed each patient.

19. The reimbursement rate geographic modification is applied to ______ % of the base rate.
   a. 60
   b. 50
   c. 40
   d. 30

20. Common supplies used for radiology that are no longer paid outside of the APC system include:
   1. image processing.
   2. contrast agents.
   3. routine supplies such as needles and syringes.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

21. The Medicare Physician Fee Schedule (MPFS) ______ component payment is for resources used to provide a service, such as the medical equipment and nonprovider staff time.
   a. professional
   b. global
   c. technical
   d. therapist

continued on next page
22. The ______ enacted a cap on the MPFS rates for the technical component of imaging procedures to be no more than the rate paid through the outpatient prospective payment system.
   a. ACA  
   b. MIPPA  
   c. Deficit Reduction Act  
   d. Balanced Budget Act

23. The ______ rate is the percentage of time a piece of imaging equipment is available to perform procedures in a 50-hour workweek.
   a. utilization  
   b. reimbursement  
   c. growth  
   d. availability

24. It is estimated that most CT and MR procedures will see a decrease in reimbursement rates of ______ % beginning in 2014.
   a. 0 to 10  
   b. 10 to 20  
   c. 20 to 30  
   d. 30 to 40

25. Accountable Care Organizations agree to do all of the following except:
   a. bill for individual services provided to Medicare beneficiaries in their group.  
   b. accept payment for total care of a patient.  
   c. share data with the CMS.  
   d. provide care to a defined group of Medicare beneficiaries for a specific amount of money.
Directed Reading Evaluation
Medicare Reimbursement

Thank you for taking the time to complete this evaluation. Your opinion helps us serve you better. Your comments will remain confidential and will not affect the scoring of your Directed Reading (DR) test. Choose only ONE response for each question. Use a blue or black ink pen. Do not use felt tip markers. Completely fill in the circles.

1. Why did you choose to complete this DR?
   - Interested in the topic
   - Topic pertained to my area of practice
   - Needed CE credits immediately
   - Other

2. How relevant is this DR to your practice?
   - Very relevant
   - Relevant
   - Somewhat relevant
   - Not relevant

3. How beneficial is this DR to your professional or personal development?
   - Very beneficial
   - Beneficial
   - Somewhat beneficial
   - Not beneficial

4. How would you rate the level of difficulty of this DR?
   - Too difficult
   - Somewhat difficult
   - Just the right level
   - Somewhat easy
   - Too easy

5. How would you rate the length of this DR?
   - Too long
   - Somewhat long
   - Just the right length
   - Somewhat short
   - Too short

6. Did this DR meet your expectations?
   - Yes
   - Partially
   - No

7. Would you recommend this DR to a colleague?
   - Yes
   - No

8. Overall, how valuable are the DRs to you?
   - Very valuable
   - Valuable
   - Somewhat valuable
   - Not very valuable

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Medicare Reimbursement: What R.T.s Should Know

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Note: For true/false questions, A=true, B=false.

1 ○●○○○○ 11 ○○○○○ 21 ○○○○○
2 ○○○○○ 12 ○○○○○ 22 ○○○○○
3 ○○○○○ 13 ○○○○○ 23 ○○○○○
4 ○○○○○ 14 ○○○○○ 24 ○○○○○
5 ○○○○○ 15 ○○○○○ 25 ○○○○○
6 ○○○○○ 16 ○○○○○
7 ○○○○○ 17 ○○○○○
8 ○○○○○ 18 ○○○○○
9 ○○○○○ 19 ○○○○○
10 ○○○○○ 20 ○○○○○

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Sample Ballot

Here are the candidates running in the 2014 ASRT election. When voting opens Feb. 13, choose one candidate for each of the three national officer positions. For national chapter delegates, choose two candidates in each category, and choose three in the Military Chapter.

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Crohn Disease: Pathophysiology, Diagnosis, and Treatment


Crohn disease (often seen in the literature as “Crohn’s disease”), an autoimmune disease with debilitating gastrointestinal and extragastrointestinal manifestations, is on the rise in the United States and Europe. This article discusses the disease process, clinical presentation, diagnostic tools, and treatment options for Crohn disease. Statistics regarding disease prevalence and epidemiology also are reported.

To understand fully how Crohn disease develops and progresses, it is essential to recognize that the gastrointestinal (GI) tract of a healthy individual is in a state of dynamic immune homeostasis, or persistent naturally occurring inflammation. The immune system is responsible for balancing factors that activate its defense system and induce inflammation while simultaneously down-regulating the inflammation to maintain mucosal integrity. Because the mucosal surfaces that line the gut are the physical interfaces of the body’s immune system with the outside world and the GI tract consists of a large portion of the body’s mucosal lymphoid tissue, it is crucial that mucosal integrity be maintained. An additional consideration is the fact that the human intestine harbors the largest and most diverse collection of microbial flora within the body, consisting of more than 500 species of commensal bacteria. These commensals, or microorganisms that share a symbiotic benefit with the intestinal environment of their host, actively moderate the expression of genes involved in several functions of the GI tract, including nutrient absorption, mucosal barrier fortification, xenobiotic (foreign chemical compound) metabolism, angiogenesis, and postnatal intestinal maturation. To maintain this relationship between the intestinal mucosa and its natural flora, immune homeostasis depends on 3 key mucosal functions: maintenance of the epithelial barrier, antigen recognition and immune regulation, and lymphoid cell response. When these mucosal functions are impaired, Crohn disease can result.

Pathogenesis
Crohn disease, often seen in the literature as “Crohn’s disease,” is a progressive, systemic autoimmune disorder marked by abnormal inflammation of the GI tract. Any part of the GI tract can be affected, from the mouth to the...
Crohn Disease: Pathophysiology, Diagnosis, and Treatment

anus. Diarrhea and abdominal pain are common symptoms, and the disease can be chronic, intermittent, or in long-term remission. Several subtypes are recognized, depending on the area of the GI tract most affected. Crohn disease is grouped with other inflammatory bowel diseases (IBDs) such as ulcerative colitis.

It is now widely accepted that IBD results from an inappropriate response of a defective mucosal immune system to the indigenous flora and other luminal antigens. Experimental evidence suggests that impairment of a variety of immune pathways might result in the initiation of potentially destructive inflammatory cascades. Compelling evidence that supports this hypothesis comes from the use of animal models of IBD, in which genes for varying inflammatory cells and receptors were individually deleted, with all cases resulting in the development of inflammation of the intestinal tract similar to IBD.

One potential area of mucosal malfunction relates to the epithelial wall’s role as a barrier. The wall of the intestinal lumen consists of 5 layers: epithelial-lined mucosal layer, submucosal layer, 2 muscular layers (inner circular and outer longitudinal), and the outer serosal layer (see Figure 1). In patients with Crohn disease, the epithelial layer often increases in permeability, allowing pathogens to leak through to the mucosal layers beneath with less resistance. This defect often precedes the clinical onset of Crohn disease in individuals with a familial risk. In fact, this “leaky bowel” impairment has even been found in healthy first-degree relatives of patients with IBD, implicating its origin as a genetic defect. As a result of microbial pathogens’ increased access to the mucosal layer and the submucosa’s numerous embedded antigen receptors, an immune response may be triggered and the inflammatory cascade initiated.

The mucosa’s role in antigen recognition, a second potential reason for immune malfunction, is a variation in the distribution of its toll-like pattern recognition receptors (TLRs). TLRs can be found throughout the luminal epithelium, and they vary in both concentration and type. TLRs are individually specialized receptors. Each TLR recognizes specific commensal microorganisms. When working in unison, they recognize the majority of intestinal microbes that make up the gut’s natural bacterial flora. Typically, the cells of a healthy patient will express TLR-3 and TLR-5 primarily, with subsequent down-regulation of the immune response due to constant receptor activation by recognized and expected commensal bacteria. However, in patients with Crohn disease, fewer TLR-3 and TLR-5 receptors are present. This results in hypersensitivity to commensal exposure, inducing an unsuppressed, aggressive inflammatory response.

A third potential complication is the mucosa’s inability to suppress an inappropriately triggered immune response. T-cells, members of a group of white blood cells (WBCs) known as lymphocytes, play a central role in cell-mediated immunity. When immune cells are not properly controlled and cleared from the body, they persist and remain activated rather than undergoing apoptosis (programmed cell death). These potential malfunctions of the intestinal mucosa and the subsequent impairment of the normal immune response are closely linked to 2 primary risk factors: genetic predisposition and exposure to various environmental antigens.

Genetic Predisposition

Genetic predisposition—especially familial aggregation—seems to be the strongest independent indicator of which individuals will develop Crohn disease.
Current research shows that among those with Crohn disease, 2.2% to 16.2% have a first-degree relative who also has the disease. Furthermore, for a first-degree relative of a patient with Crohn disease, the estimated lifetime risk of developing Crohn disease ranges from 4.8% to 5.2%, making first-degree relatives 3 to 20 times more likely to develop the disease than those without the familial connection. Furthermore, the risk for a sibling of a patient with Crohn disease is even higher than the average risk for a first-degree relative.

Regarding ethnicity, similar data have shown that for an individual of European Jewish (Ashkenazi) descent, the estimated lifetime risk for those with a first-degree relative who has Crohn disease increases to 7.8%, making them 3 to 5 times more likely to develop the disease than non–Ashkenazi Jews who also have a first-degree relative with Crohn disease. In fact, Crohn disease is more prevalent in Ashkenazi Jews than in any other ethnic group.

Crohn disease has been characterized as a polygenic disease process. Genome-wide scans show susceptibility loci for Crohn disease on multiple chromosomes that play a potential role in development of the disease. Regions on chromosomes 16q, 12, 6, 14, 5, 19, 1, 16p, and 10 have been renamed IBD1 to IBD9, respectively, indicating their involvement in the IBD process. Mutations to several of these loci have been found to affect an individual’s systemic immune response directly. For example, the product of a mutation on the IBD1 locus of chromosome 16q has been found to influence the regulation of macrophages, and in essence the immune-inflammatory response. Another example can be found on chromosome 6 (IBD3), a region that plays an important role in autoimmunity.

Because a mutation on any 1 or several of the IBD loci can activate specific immunologic response pathways, certain mutations in these loci might be associated with certain Crohn disease courses. For instance, the IBD1 locus, which is associated exclusively with the disease in white populations, has been associated with the stricturing form of Crohn ileitis (inflammation in the small intestine), and IBD3 has been linked to Crohn colitis (inflammation in the large intestine). Furthermore, extraintestinal disease complications have been linked to other Crohn-related genetic mutations. Conversely, some mutations recently have been described as possibly protecting against Crohn disease.

When considering the effect of genetic predisposition for Crohn disease, it is important to note that the relative risk of developing the disease for an individual with a mutation in one of the IBD gene loci is fairly low (approximately 1:200). This data supports the understanding that environmental factors also must be involved as a trigger for the expression of the genetic mutation.

**Environmental Risk Factors**

Geographical data indicate that, although rates of Crohn disease incidence are stabilizing in high-incidence regions, low-incidence regions are showing an increase in the number of diagnosed cases. The highest incidence rates and prevalence of reported Crohn disease cases are in the northern hemisphere, particularly Northern Europe (27-48 cases per 100 000); the United States has 3 to 5 cases per 100 000. In contrast, the countries with the lowest incidence rates and prevalence of reported cases are in the southern hemisphere, specifically South America, Southeast Asia, Africa (with the exception of South Africa), and Australia. For example, rates measured at a hospital in Argentina were 0.03 per 100 000. Although the data suggest that a gradient exists between northern and southern continents, they also suggest that other factors are involved. Socioeconomic status, including access to and quality of health care, sanitation standards and hygiene practices, and dietary habits, likely play a role, although not in the way one might expect.

Rural communities in developing regions of China suffer from limited access to and lower quality of health care facilities and related services. However, a study showed increasing incidence rates of Crohn disease among immigrants from low-incidence regions of China who moved to more developed regions of the country. Furthermore, a lower risk of developing Crohn disease has been associated with factors such as an absence of tap water, absence of hot water, large or poor families, crowded living conditions, and consumption of contaminated foods—all factors related to a low socioeconomic status. The theory behind this counterintuitive phenomenon is that excessive sanitation might limit exposure to environmental antigens and impair the functional development of the mucosal immune system, followed by subsequent immune intolerance to...
some environmental antigens. Although there is no evidence that Crohn disease is directly caused by luminal microbes, it is quite likely that these microbes indirectly provide the antigenic trigger to a fundamentally dysregulated immune system. This concept is strengthened by the observations in animal experiments that have shown IBD to develop in the presence of normal gut flora but not in germ-free mice.  

A third possible factor in the correlation between decreased incidences of Crohn disease and socioeconomic status is diet. A positive correlation between the disease incidence and increased intake of meat protein, milk protein, and polyunsaturated fatty acids has been reported. A negative correlation between disease incidence and consumption of vegetable protein also was reported, with no correlation determined regarding consumption of fish-based protein. Numerous diet-focused studies have shown a strong link between a country’s socioeconomic status (ie, industrialized vs developing) and an increased prevalence of animal-based proteins in the standard diet of economically prosperous communities. However, it is important to note that dietary studies often have weaker research methods because of poor patient compliance or recall, making interpretation of the findings difficult.

**Manifestations and Complications**

The Vienna classification was developed to describe the distinct clinical phenotypes of Crohn disease with respect to disease location and potential complications (see Table 1). According to the data, at diagnosis the disease is located at the:

- Terminal ileum (Crohn ileitis) in 47% of patients.
- Colon (Crohn or granulomatous colitis) in 28%.
- Ileo colon (Crohn ileocolitis) in 21%.
- Upper gastrointestinal tract (Crohn jejunitis, gastroduodenal Crohn disease, or Crohn disease of the esophagus) in 3% of the cases.

In addition, the disease can be further classified as strictureing in 17% of patients, penetrating (fistulae, abscesses, or both) in 13%, and nonstricturing and nonpenetrating in 70% of all patients at diagnosis. It is important to note that Crohn disease is a chronic, progressive disease, and patients often develop complications as the inflammation reaches additional segments of bowel.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Vienna Classification of Crohn Disease Phenotypes</th>
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<tr>
<td>Variables</td>
<td>Subgroups</td>
</tr>
<tr>
<td>Age at diagnosis</td>
<td>&lt; 40 years</td>
</tr>
<tr>
<td>Location of disease</td>
<td>Terminal ileum</td>
</tr>
<tr>
<td>Behavior</td>
<td>Nonstricturing nonpenetrating</td>
</tr>
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</table>

Regardless of the inflammatory pathway triggered, there are general initial features of the inflammatory process that are common to the development of inflammatory bowel disorders. Upon activation of the body’s immune response system by commensal bacteria, migration of inflammatory cells from the vasculature system flood into the intestinal mucosa at the site of the inflammatory trigger. A multitude of aggressive metabolites and mediators accumulates in the mucosal tissue, resulting in tissue damage. Such metabolites include nitric oxide, oxygen radicals, prostaglandins, leukotrienes, and histamines, all released at the site of inflammation and subsequently promoting fibroblast growth, collagen secretion, and varying degrees of luminal stricture formation.

When there is narrowing of the intestinal lumen, patients with Crohn disease are in danger of developing a mechanical intestinal obstruction, a complication of the disease in which the intestinal pathway becomes occluded. A bowel obstruction can occur at any level distal to the duodenum and is considered to be a medical emergency. In rare cases, intestinal inflammation and obstruction can result in toxic megacolon, an acute form of colonic distention in which the colon becomes grossly dilated. This condition can cause decreased tissue perfusion with subsequent septic shock if the bowel is perforated. About 27% of patients who do not display evidence of strictureting at the time of Crohn disease diagnosis develop luminal strictureting as their disease progresses. The focal infiltration of inflammatory neutrophilic cells into the intestinal epithelium typically occurs at
areas overlying lymphoid aggregates called Peyer patches, usually found in the ileal segment of the small intestine. In addition, neutrophils can infiltrate the intestinal crypts (glands in the intestinal wall responsible for generation of new epithelium) and with chronic irritation lead to cryptitis. If the inflammation is not suppressed, the inflamed crypt cells can progress into ulcers, an outcome seen in highly active disease states. A characteristic more specific to Crohn disease and often used to differentiate it from other inflammatory bowel pathologies is the abrupt transition between the unaffected and the ulcerated tissues. Known as skip lesions, these can develop throughout the diseased segments of bowel, with some segments being affected but not others. In addition, one side of the intestinal wall can be affected but not the other.1,9

A second Crohn disease–specific manifestation is a transmural pattern of inflammation, with evidence of inflammation spanning the entire depth of the intestinal wall.1 The inflammation begins in the submucosa and spreads to the mucosa and serosa. With the development of serositis, the serosa becomes granular and dull gray in appearance, with the intestinal wall taking on a rubbery texture. Furthermore, serosal extension of mesenteric fat (creeping fat) might wrap around the bowel surface and often is used for staging the disease’s progression.2

In early stages, focal mucosal ulcers might develop and can resemble canker sores (aphthous ulcers) (see Figure 2). As the disease progresses, multiple ulcers can unite into longitudinal or transverse linear serpentine fissures that can extend into the intestinal lymphoid tissue. In some cases, a disease complication can arise when these ulcerations in the bowel wall traverse the entire thickness of the organ’s tissue and form fistulae between an inflamed segment of bowel and an adjacent anatomical structure.

Fistulae can form between the diseased bowel segment and another loop of bowel (enteroenteric), the bladder (enterovesical), the vagina (rectovaginal), skin (enterocutaneous), or the peritoneal cavity (see Figure 3). With the development of multiple fistulae, chronic blood loss often results in anemia. In addition, proliferation of commensal bacteria within the peritoneal cavity can result in peritonitis, inducing further inflammation in the form of abdominal ascites. The location of fistula development depends on the Crohn disease phenotype, with formation occurring at sites of excessive inflammation throughout the GI tract. In cases of penetrating Crohn disease, about 29% of patients who have received a Crohn disease diagnosis but who do not display evidence of fistulae will develop luminal fistulae as their disease progresses.3

Figure 2. Double-contrast barium enema examination in Crohn colitis demonstrates numerous aphthous ulcers. Image reprinted with permission from David I Weltman, MD, published by Medscape Reference.

Figure 3. Double-contrast barium enema study demonstrates multiple fistulous tracts between the terminal ileum and the right colon adjacent to the ileocecal valve, the so-called double-tracking of the ileocecal valve. Image reprinted with permission from David I Weltman, MD, published by Medscape Reference.
Another finding associated with chronic Crohn disease–related inflammation is the presence of granulomas. These occur in about 50% of all Crohn disease types and consist of spherical aggregations of immune cells (specifically, giant cells) that develop when the immune system is attempting to wall off substances recognized as foreign. Granulomas can occur anywhere in the alimentary tract. In patients with Crohn disease limited to one bowel segment, they typically are found within the large intestine. The granulomas that form with Crohn disease are the noncaseated type, meaning they do not exhibit a “cheeselike” appearance of tissue necrosis. Often, the intestinal lining takes on a cobblestone appearance as a result of granulomatous projections of inflamed tissue surrounded by areas of ulceration (see Figures 4 and 5).2,10

One last potential disease complication is related to the chronic inflammatory aggravation of the mucosal tissue that often can lead to architectural distortion, atrophy, and even metaplastic cellular changes. If left untreated, the persistent activation of the inflammatory response associated with Crohn disease leads to a 5- to 6-fold increase in the risk of developing cancer. Depending on the location of the inflammation, patients with Crohn disease can be at risk for developing lymphoma or cancer of the small bowel and colon.3

Although Crohn disease exhibits primarily GI-specific manifestations, it is important to remember that it is a systemic autoimmune disorder, and Crohn disease patients often present with an array of extragastrointestinal manifestations. Crohn disease can be associated with comorbidities involving almost all organ systems (see Box).1 Individuals with Crohn disease also are at risk of developing other disease complications as a result of malnutrition due to decreased food intake associated with painful digestion and impairment of epithelial cell absorption of dietary nutrients.

After the first year following diagnosis, 10% to 30% of patients with Crohn disease have an exacerbation of symptoms, 15% to 25% maintain low disease activity, and 55% to 65% have disease remission. Furthermore, 13% to 20% of patients with Crohn disease have chronic activity, 67% to 73% have a chronic-intermittent course, and 10% to 13% remain in remission for several years.13 The life expectancy of patients with Crohn disease is reduced slightly, and quality of life can be greatly impaired.
Diagnosis

Crohn disease diagnosis is based on many clinical features. The initial step is a thorough investigation of the patient's presenting symptoms, including any related medical, social, and family history. This is followed by a focused physical examination of the abdomen and any other symptom-related body systems. If, based on the history and physical examination, Crohn disease is a potential diagnosis, most clinicians check for nonspecific inflammatory activity with a variety of simple laboratory tests, including an erythrocyte sedimentary rate (ESR), C-reactive protein (CRP), and leukocyte and platelet count. Finally, medical imaging can be used to confirm diagnosis and monitor disease activity.

Patient History

Crucial information can be garnered prior to meeting the patient by reviewing his or her demographic information such as age, sex, and race. This information can be used to determine whether the patient falls into groups associated with increased incidence of Crohn disease. The disease presents typically in a bimodal distribution, with the highest occurrence initially in individuals between the second and third decades of life and a minor incidence peak between the sixth and seventh decades.\(^4\) As for sex, incidence is slightly higher among women than men.\(^1^1\) Lastly, race also has been shown to play a role in the development of Crohn disease in North America, with prevalence rates for Hispanic (4.1 per 100 000) and Asian (5.6 per 100 000) individuals being much lower than those for white (43.6 per 100 000) and African American (29.8 per 100 000) individuals.\(^1^1\)

The chief complaints with inflammatory bowel disorders are diarrhea, abdominal pain, malaise, low-grade fever, and unintended weight loss. When assessing the onset of potential IBD symptoms, it is important to note that the disease often is present for months or even years before the symptoms manifest and a diagnosis can be made.\(^4\) Because of the intermittent nature of these diseases, it is possible that the patient has been experiencing the symptoms for some time, and only as they have increased in severity has he or she decided to seek medical intervention.

The location of symptomatic pain is often one of the strongest indicators of Crohn disease type. If the patient complains of pain in the right lower quadrant of the abdomen, this could indicate a case of ileocecal Crohn disease. However, pain in the right lower quadrant, especially when associated with a high fever, also can indicate acute appendicitis, which should be ruled out with confidence because it can lead to a life-threatening emergency.

When the patient suffers from a Crohn flare-up, symptoms usually occur simultaneously. The length of time between symptom relapses often is noted, and a progressive decrease in time between Crohn flare-ups can indicate progression of the disease.

The pain associated with Crohn disease typically is crampy and colicky in nature, consistent with most forms of bowel inflammation. The patient reporting blood in his or her stool can be a strong indicator of whether the disease has colonic involvement. The more proximal the inflammatory disease is within the GI tract, the less likely the patient’s stool will be noticeably red. Instead, it will appear dark, almost black. This is known as melena. Blood from the lower GI tract appears brighter red and is known as hematochezia. Melena is present in approximately 50% of Crohn disease cases,\(^4\) with Crohn ileitis rarely being associated with bloody stool and Crohn colitis presenting with only minor amounts of blood. It also is important to question the presence of any genitourinary symptoms because fistulae that form between the intestinal tract and the bladder can exhibit either blood or fecal matter in the urine, as well as urinary tract infections.

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**Box**

**Comorbidities Associated With Crohn Disease**

- Migratory polyarthritis.
- Erythema nodosum.
- Pyoderma gangrenosum.
- Pleuritis.
- Myocarditis.
- Hepatic pericholangitis and sclerosing cholangitis.
- Obstructive uropathy with kidney stones (with associated predisposition to urinary tract infections).
- Pancreatitis.
- Ankylosing spondylitis.
- Sacroiliitis.
- Various neurological conditions.

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*Note: The information provided is for educational purposes only and should not replace professional medical advice.*
A few possible aggravating factors can hasten the progression of Crohn disease and magnify the presenting symptoms. Often, eating exacerbates abdominal pain because of the passage of food through the inflamed portion of colon. Because of the fairly common presence of lactose intolerance, dairy products can be problematic foods. If the patient is suffering from a bowel obstruction, high-fiber foods such as raw fruits, vegetables, and nuts can enhance abdominal pain. If the location of the bowel inflammation is localized to the terminal ileum—the site at which the body absorbs most dietary fat—fat malabsorption can result, often leading to worsening diarrhea. In addition, cigarette smoking is strongly associated with the development of Crohn disease, resistance to medical therapy, and early disease relapse.³ Use of nonsteroidal antiinflammatory drugs (NSAIDs) also can exacerbate IBD, possibly leading to NSAID-induced colitis characterized by small bowel and colonic ulcers, erosion, or strictures.¹⁴

When evaluating the patient’s diet, it is important to note that a positive correlation has been reported between Crohn disease and intake of meat protein, milk protein, and polyunsaturated fatty acids.⁸

A subjective evaluation of the severity of the patient’s symptoms, such as asking the patient to rate his or her pain on a 10-point scale, can be useful. The higher the pain ranking, the more likely the inflammation is transmural in nature, potentially structuring and obstructing abdominal contents or fistulizing to nearby organs. The number of liquid bowel movements per day also can be used to measure the severity of the disease course.

A final symptom that might be reported is unintended weight loss. There are multiple potential contributing factors for a sudden and unexpected decrease in weight. The most obvious reason is severe, watery diarrhea, which results in decreased water-specific weight as well as dehydration. Another cause is pain associated with digestion that discourages the patient from eating. In addition, a subset of patients could develop sinus tracts that penetrate the bowel and form fistulae from the colon to the small intestine or stomach, which can result in bacterial overgrowth and subsequent diarrhea, weight loss, and malnutrition.¹⁴ Depending on the location of the involved bowel segment, various nutrient deficiencies can develop, including B₁₂ deficiency and hypoalbuminemia. Nutrient deficiencies are most common when the ileum is affected. Furthermore, calculi often form in the kidneys or gallbladder as a result of fat malabsorption.⁴

A thorough medical history also should include immunizations the patient has received. There is a hypothesis that the attenuated live measles, mumps, and rubella vaccine might increase the risk of IBD,³ and although evidence to support this view is relatively weak, knowledge of the hypothesis might be useful.

**Physical Examination**

The physical examination should capture the following vital signs: blood pressure, respiratory rate, heart rate, and temperature. Mild elevation in temperature often signifies the presence of an underlying inflammatory process such as Crohn disease.

During the abdominal examination, patients with the penetrating form of Crohn disease might present with fistulae that form between the intestinal tract and the overlying dermal layer (enterocutaneous fistulae). These occur most often at the site of surgical scars.¹³ Abdominal distention due to prolonged bloating might be visible and can indicate intestinal obstruction, a characteristic complication of Crohn disease. Movement of the abdomen from peristalsis of the intestinal tract usually is not visible; rippling movements indicate possible intestinal obstruction.¹⁵

Auscultation (listening to bowel sounds) should precede percussion because the maneuvers associated with percussion might alter the frequency and intensity of the bowel sounds. Adequate auscultation of bowel sounds requires a minimum of 5 minutes of listening, incorporating all 4 quadrants of the abdomen (right upper, right lower, left upper, and left lower). Although the sounds usually are generalized for the entire abdomen, areas that exhibit high-pitched tinkling sounds suggest fluid and air under pressure, and thus an early bowel obstruction.¹⁴ Often, loud prolonged gurgles, called *borborygmi*, can be heard. These also are a potential sign of intestinal obstruction.¹⁴

When performing percussion of the abdominal cavity, the degree of percussion tone will vary depending on the size and density of the organs within the abdomen. The percussion tone is loud over air, less loud over fluid, and soft over solid areas. Typically
values. An increased total WBC count (leukocytosis ≥ 10,000) usually indicates infection, inflammation, or tissue necrosis. Emotional stress also can increase the value. It is important to note that patients who have had a splenectomy often also have persistent mildly to moderately elevated WBC counts. A decreased total WBC count (leukopenia ≤ 4,000) occurs in many forms of bone marrow failure and can be a result of dietary deficiencies and autoimmune disorders. In addition, values tend to be lower in the morning and higher in the late afternoon. Serial WBC counts have both a diagnostic and prognostic value.

CRP is an acute, phase-reactant protein that indicates the presence of an inflammatory process. Under normal circumstances, it is produced by hepatocytes in low quantities, with average values ranging from 1.0 to 3.0 mg/L. The synthesis of CRP is initiated by antigen-immune complexes, bacteria, fungi, and trauma. Measuring a patient’s CRP levels provides the clinician with a non-specific confirmation of both infections and inflammatory disorders; elevated CRP levels often are seen with tissue necrosis. Table 2 summarizes the diagnostic significance of elevated CRP by level.

In the presence of inflammatory changes, the CRP shows an earlier and more intense increase than ESR and, conversely, with recovery, CRP returns to a normal level preceding the subsequent return of ESR to a normal level as well. The CRP decreases when the inflammatory process is suppressed by antiinflammatory agents, salicylates, or steroids. Elevated test results can be due to hypertension, elevated body mass index, metabolic syndrome/diabetes mellitus, chronic infection (e.g., gingivitis, bronchitis), chronic inflammation (e.g., rheumatoid arthritis), and low levels of high-density lipoprotein/high triglycerides. Cigarette smoking also can increase CRP levels, whereas moderate alcohol consumption, weight loss, and increased activity or endurance exercise can decrease levels.

Laboratory Tests

The patient history and physical examination should yield enough information to provide a short list of potential differential diagnoses. However, often the subjective information garnered from the patient interview and the limited objective information obtained from the physical examination are not enough to make a confident final diagnosis. When Crohn disease is the most likely diagnosis, clinicians often use a variety of laboratory tests and medical imaging procedures to help provide concrete evidence of the disease.

Several laboratory tests can confirm the presence of nonspecific inflammatory activity, including ESR, CRP, and leukocyte and platelet counts. Caution should be exercised when evaluating the results of these lab tests, however, because some medications can increase or decrease lab values.

A total WBC count is part of most routine laboratory diagnostic evaluations. This test consists of 2 components. The first is a count of the leukocytes in 1 mm³ of peripheral venous blood. The other component, the differential count, measures the percentage of each type of leukocyte present in the same specimen. Neutrophils and lymphocytes make up 75% to 90% of the total leukocytes; the remaining WBCs include monocytes, eosinophils, and basophils.

Although the total leukocyte count has a wide range of normal values, many diseases can induce abnormal

<table>
<thead>
<tr>
<th>CRP Level (mg/L)</th>
<th>Probable Cause</th>
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<tbody>
<tr>
<td>10-50</td>
<td>Viral infection</td>
</tr>
<tr>
<td>50-200</td>
<td>Bacterial infection</td>
</tr>
<tr>
<td>200-250</td>
<td>Burns</td>
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Abbreviation: CRP, C-reactive protein.
ESR is another nonspecific test used to detect illnesses associated with acute and chronic infection, inflammation, advanced neoplasms, and tissue necrosis or infarction. ESR is a measurement of the rate at which the red blood cells settle in a saline solution or plasma over a specified period. It is not diagnostic for any particular disease or injury. Because inflammatory, neoplastic, infectious, and necrotic diseases increase the protein (mainly fibrinogen) content of plasma, red blood cells have a tendency to stack up on one another, increasing their weight and causing them to descend faster. Therefore, the ESR is increased in these diseases. Compared with CRP, ESR peaks more slowly and can take several days to decrease, even if the clinical condition is ameliorated. The ESR is a fairly reliable indicator of the course of disease and therefore can be used to monitor disease progression, especially for inflammatory autoimmune diseases such as Crohn disease. In general, as the disease worsens, the ESR increases, and as the disease improves, the ESR decreases. If the ESR results are equivocal or inconsistent with clinical impressions, the CRP test is then performed. The Westergren method for interpreting normal ESR lab values is both age- and sex-dependent, with normal values for men being 15 mm/hr and up to 20 mm/hr for women. For children, a normal ESR level is typically no higher than 10 mm/hr, with the levels of infants being no higher than 2 mm/hr.

One other laboratory test that usually is ordered to aid in GI-related diagnoses is a guaiac test, in which a stool sample is obtained during the rectal examination to check for occult blood. To rule out other potential causes of abdominal pain and diarrhea, a stool sample also might be checked for bacterial pathogens, parasites, leukocytes, and Clostridium difficile infection.

**Imaging Examinations**

**Radiography**

After laboratory testing, the next step is to perform imaging examinations that can confirm a Crohn disease diagnosis. No single imaging procedure uniformly confirms Crohn disease, and often a variety of procedures must be used to make up for limitations associated with each examination.

The typical approach to conducting an imaging work-up for potential Crohn disease is to first conduct generalized imaging of the patient’s abdominal-related symptoms. Obtaining abdominal radiographs (including upright, supine, and lateral decubitus images using standard x-ray equipment without the use of contrast agents) can reveal evidence for several patient complaints. Dilated bowel loops, air-fluid levels, excessive amounts of stool, or bowel loop displacement often can be indicative of possible bowel perforation, obstruction, or organomegaly. For this reason, abdominal radiographs are most useful in the initial evaluation of abdominal pain or nausea and vomiting. In addition, static radiographic images identify extraintestinal calcifications related to gallbladder or kidney stone formation that occasionally accompany Crohn disease in patients with severe malabsorption issues.

Further imaging specifically related to small bowel radiography includes contrast-enhanced upper GI and small bowel follow-through procedures. Contrast agents such as barium or water-soluble diatrizoic acid (Gastrografin) can be administered by mouth or rectum to detect mucosal abnormalities such as ulceration and masses, strictures, and abnormal peristalsis. The contrast can be used alone as a single contrast agent or in combination with air- or gas-forming crystals as part of a double-contrast technique. Single-contrast examinations usually are used to detect obstructing lesions or motility disturbances, while the double-contrast examination aids in detecting more subtle ulcerations in the mucosal wall. During the upper GI series, serial radiographic images are obtained as the contrast is ingested, providing information about abnormalities of the esophagus, stomach, and duodenum.

Current data suggest that 70% of all patients with Crohn disease have some involvement of the small bowel during the course of their disease, with 30% of those having Crohn manifestations limited to the small bowel. Therefore, the small bowel follow-through examination in which the contrast is visualized as it passes into the jejunum and ileum is highly important. During this procedure, the radiologic technologist or radiologist assistant obtains multiple close-up views (often referred to as spot films) of areas that seem abnormal. This might require some external, manual compression of the patient’s abdomen to help better position the intestinal area of interest and reveal any concealed pathology. A variation of the examination might include placement of a nasal enteric tube for a technique called...
enteroclysis in which contrast material is introduced rapidly into the intestinal tract below the duodenojejunal junction. The goal is to bypass the stomach and introduce a large bolus into the small bowel, resulting in optimal filling, dilation, and visualization of the intestinal tract.

Attention should be paid to structural abnormalities as well as the length of time required for contrast to reach and traverse the various segments of the colon. Prolonged digestion of the contrast often indicates a potential bowel obstruction due to bowel wall thickening and subsequent stricture. When a bowel stricture is present, the GI “string” sign should be as well (see Figure 6). This radiographic finding resembles a thin string of frayed cotton and is caused by a thin stream of contrast working its way through the narrowed GI pathway.

Computed Tomography

Computed tomography (CT) also can be useful for diagnosing Crohn disease. CT provides computer-aided reconstruction of multiple radiographic images collected in a helical course around a supine patient. Contrast agents can be used to opacify the bowel lumen, revealing the caliber and contour of the GI tract and allowing diagnosis of inflammatory lesions. CT’s ability to visualize the entire abdominal cavity also allows for detection of parenchymal lesions such as abscesses and granulomas in the bowel wall, as well as defining the size, shape, and characteristics of extraintestinal abdominal organs. In some cases, splenomegaly occurs as a sign of liver destruction related to Crohn disease. Furthermore, a CT scan can provide a differential diagnosis when Crohn disease–related pain in the right lower quadrant mimics appendicitis by isolating and evaluating the appendix for signs of inflammation.

CT enteroclysis can offer visualization of the extraluminal bowel wall that endoscopy using a wireless capsule cannot. Using the enteroclysis technique of injecting a contrast bolus through a nasojejunal tube, CT enteroclysis can detect segmental bowel thickening, extraluminal lesions, fistulae, and abscesses, all within a relatively short time. The modality’s ability to detect fistulae, often associated with the transmural inflammation characteristic of Crohn disease, is of greatest value because this information often leads to a change in the patient’s pharmacologic treatment. Early data suggest that CT enteroclysis studies are at least equivalent, if not better than, the current small bowel follow-through.

However, CT scanning does have drawbacks. During an abdominal CT, patients are exposed to a considerable amount of radiation, with a mean cumulative effective dose of 36.1 mSv, although doses of more than 75 mSv are possible. This is far more than the dose received during a routine small bowel radiography procedure. Because Crohn disease has an initial peak during the second and third decades of life and the body is at a heightened sensitivity to the effects of radiation at this time, imaging techniques that use less radiation or no radiation should be considered. Another limitation of the CT examination is that collapsed loops of bowel often create artifacts that distort pathology, and the lack of dynamic imaging capabilities makes it difficult to differentiate between peristalsis...
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and skip lesions, a prime distinguishing manifestation of Crohn disease. The inability to identify skip lesions can lead to misdiagnosis.

Magnetic Resonance Imaging

Similar to CT, magnetic resonance (MR) imaging can provide multiple cross-sectional images of the abdomen and pelvis. However, unlike CT, MR can be performed with respiratory compensatory tools and faster pulse sequences to reduce artifacts caused by breathing or peristalsis, allowing differentiation between peristalsis and Crohn disease-related skip lesions. Because of its multiplanar capabilities and ability to distinguish inflammatory damage, MR can affect disease management and the decision to perform surgery vs a pharmacologic approach only.

As with fluoroscopic and CT imaging examinations, an enteroclysis technique can be used with MR to better visualize the intestinal walls; however, because of the difference in image collection methods, a polyethylene glycol solution is used as the contrast material. Furthermore, MR can visualize parenchymal lesions such as masses and cysts and might better characterize abnormalities seen on CT. MR imaging also is considered to be better at characterizing perirectal abscesses and fistulae related to Crohn disease. Perhaps most important, especially considering younger patient populations, MR avoids the radiation exposure associated with most other imaging modalities.

Two potential limitations of the MR imaging examination, however, are the relatively small bore in which the patient must fit during the imaging procedure, as well as the hour-long examination time during which absolute stillness is required to attain images free of motion artifacts. Often these testing requirements prove challenging to patients who suffer from even mild forms of claustrophobia, as well as those who are in critical condition and require constant monitoring of vital signs.

Endoscopic Techniques

Small bowel radiography mostly has been superseded by endoscopic examination for Crohn disease diagnosis because the endoscope is more sensitive for detecting mucosal abnormalities and also allows clinicians to obtain mucosal biopsies and resect lesions. Endoscopy can be performed either in an anterograde fashion using a gastroscope, push enteroscope, or double balloon enteroscope, or retrograde via a colonoscope. Although the gastroscope is useful for assessing upper GI-related issues, it is limited to the third and sometimes fourth portions of the duodenum. Furthermore, examination of the small intestine past the ligament of Treitz is not feasible with a standard gastroscope, and thus push enteroscopy with a long (≥200 cm) endoscope can be used. However, advancing this instrument beyond the first 50 cm of jejunum can prove difficult.

In such cases operative enteroscopy can be used, in which a surgeon makes a small incision in a patient’s abdomen and pleats the small bowel onto the enteroscope while the endoscopist examines the luminal surface. This procedure usually is selected only when the surgeon intends to proceed directly to a resection of the affected intestine.

A traditional nonradiographic method for assessing Crohn disease is colonoscopy with ileoscopy. Colonoscopy is an endoscopic examination of the colon with a fiber-optic camera on a flexible tube passed retrograde through the anus. In addition, the distal part of the small bowel can be examined through techniques known as ileal intubation and ileoscopy in which the scope is passed through the cecum. Anterograde intubation through the esophagus also can be conducted, reaching as far as the third and fourth portion of the duodenum via use of a gastroscope. The goal of the procedure is to provide visual confirmation of luminal destruction as
well as an opportunity for biopsy of abnormal tissue or therapeutic intervention.\textsuperscript{19} Collected tissue can be analyzed histologically for microscopic evidence of Crohn disease. These examinations rarely allow visualization of the entire small bowel; thus, the true extent of disease must be examined using an alternate procedure.

Two variations of the traditional colonoscopy procedure include the push enteroscope and double-balloon enteroscopy. The push enteroscope is simply an elongated version of the gastroscope used to visualize as far as the jejunum. To assess as far as the ileum, however, use of the double-balloon enteroscope is necessary (see Figure 7). In this procedure, 2 balloons spaced several centimeters apart on an enteroscope device are systematically inflated and deflated in sequence, allowing the enteroscope to be advanced through long stretches of small intestine, barring any impassable strictures. This procedure avoids the problem of stretching or looping of the small bowel that is associated with traditional endoscopy.\textsuperscript{18} In fact, by combining an anterograde and retrograde approach, the entire small bowel can be investigated in more than 86% of patients.\textsuperscript{20} Adequate access to the small intestine enables successful therapeutic interventions, including cauterization of lesions and treatment of GI bleeding.

Complications of endoscopy include bleeding after biopsy (0.3%-1%), perforation (0.05%-0.5%), and sedation-associated hypotension and hypoxia (1%-5%). As a result, the patient population for this procedure is somewhat limited.

The desire to visualize the GI lumen in the least invasive way prompted development of wireless capsule endoscopy, in which the patient swallows a pill-sized camera measuring 11 mm by 26 mm, and pictures are taken remotely for review by a clinician without the need for patient sedation (see Figure 8). However, even this relatively noninvasive examination has contraindications, specifically in patients with bowel strictures identified with abdominal imaging. Because of concern about possible capsule entrapment and the need for subsequent surgical intervention to remove the device in cases involving intestinal stricture, a recently developed capsule shell dissolves, allowing the intracapsular fragments to disassemble and pass through the stricture.\textsuperscript{18} However, because of the procedure’s high cost, which ranges between $20 000 and $30 000, use in the general population is far from routine, especially when other more cost-efficient imaging methods can provide similar information.

**Treatment**

**Pharmacologic Approaches**

Traditionally, treatment for Crohn disease primarily depended on pharmacologic therapies, with surgical intervention when necessary. Medications are prescribed based on the stage of disease process (active disease or remission), level of disease activity (mild to moderate, moderate to severe, or severe to fulminant), and evidence of penetrating behavior (fistulae). In clinical practice, a patient has mild-to-moderate disease activity when he...
Crohn Disease: Pathophysiology, Diagnosis, and Treatment

or she is ambulatory and can tolerate oral alimentation without manifestations of dehydration, toxicity, abdominal tenderness, or a painful mass or obstruction. In addition, these patients have lost less than 10% of their body weight. Moderate-to-severe disease activity is characterized by failed treatment for mild disease, more prominent symptoms of fever, weight loss, abdominal pain or tenderness, intermittent nausea and vomiting without obstruction, or significant anemia. Finally, severe-to-fulminant disease activity is characterized by persistent symptoms while on corticosteroids, high fever, persistent vomiting, evidence of intestinal obstruction, rebound tenderness, cachexia, or evidence of an abscess.13

Patients achieve remission when they are asymptomatic or without inflammatory sequelae, including patients who responded to medical or surgical intervention without evidence of residual disease. Steroid-dependent patients, however, are not considered to be in remission.1 Many pharmacologic therapies for Crohn disease are associated with serious adverse effects, and patients must be monitored carefully for changes in their condition. Adverse effects for commonly used drugs are summarized in Table 3.

Sulfasalazine

When treating a patient with active disease, the primary goal is to induce a state of remission, accomplished by reducing the presence of focal mucosal inflammation while simultaneously controlling the immune system’s inflammatory response, thus preventing further inflammatory destruction. In general, the first-line therapy for patients with mild-to-moderate disease activity is the antibiotic drug sulfasalazine.1 A derivative of mesalazine, sulfasalazine is used to induce remission in active disease, especially for those with colonic involvement. As a sulfonamide, it is a synthetic analog of p-aminobenzoic acid. Because of this structural similarity to p-aminobenzoic acid, sulfonamides compete with the substrate for the bacterial enzyme dihydropteroate synthetase (found in local intestinal flora), which synthesizes p-aminobenzoic acid into folic acid. By inhibiting the synthesis of folic acid available to enterobacteria, they are left without the nucleic acids needed to create DNA and RNA and thus cannot divide and proliferate.2 However, sulfasalazine is contraindicated in patients who have sulfa-related intolerance. In such cases, mesalazine would be prescribed instead. Although mesalazine is a widely prescribed antiinflammatory agent, a meta-analysis of the 3 largest trials evaluating the drug failed to show a clinically significant improvement. Thus, its routine use is controversial.4

Corticosteroids

Another class of antiinflammatory agents often used to aid induction of remission in Crohn disease patients is corticosteroids. Used particularly for patients with moderate-to-severe disease, these drugs dramatically reduce inflammation by redistributing leukocytes to other body compartments, thereby lowering their blood concentration and function. A recent population-based study reported that 44% of patients with Crohn disease needed corticosteroids to achieve remission. After 4 weeks of use, 58% of patients achieved complete remission and an additional 26% achieved a partial

<table>
<thead>
<tr>
<th>Drug</th>
<th>Possible Adverse Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic corticosteroids</td>
<td>Acne, infection, ecchymoses, hypertension, hirsutism, petechial bleeding, striae, diabetes mellitus, osteonecrosis, osteoporosis, myopathy, psychosis, cataracts, and glaucoma</td>
</tr>
<tr>
<td>Azathioprine and 6-MP</td>
<td>Pancreatitis, fever, rash, arthralgia, malaise, nausea, diarrhea, thrombocytopenia, hepatitis, veno-occlusive disease, leukopenia, infection, and lymphoma</td>
</tr>
<tr>
<td>Methotrexate</td>
<td>Rash, nausea, diarrhea, mucositis, hypersensitivity pneumonitis, bone marrow suppression, infection, and hepatic fibrosis or cirrhosis</td>
</tr>
<tr>
<td>Anti–TNF-α antibodies</td>
<td>Infusion reactions, delayed hypersensitivity reactions, formulation of autoantibodies, demyelination, drug-induced lupus, worsening of congestive heart failure, reactivation of latent tuberculosis, infections, non-Hodgkin lymphoma, and possibly solid tumor malignancies</td>
</tr>
</tbody>
</table>
response. In addition, after 1 year of corticosteroid use, 32% achieved a prolonged response. However, at the 1-year benchmark, 28% of the patients became steroid dependent, and 40% still required surgical intervention.\(^1\) Corticosteroids work by inhibiting fibrin deposition, leukocyte migration, fibroblast proliferation, and scar formation that can occur with persistent mucosal inflammation. More specifically, corticosteroids enter cells and combine with steroid receptors in the cytoplasm. Upon making this link, they enter the cell nucleus where they modify the synthesis of proteins, forming a protein that inhibits the enzyme phospholipase A\(_2\), which is needed to supply arachidonic acid, essential for the formation of inflammatory mediators.\(^2\)

In patients requiring treatment for Crohn ileitis or ileocolitis, budesonide is the corticosteroid of choice because of its targeted delivery to the ileum and right colon via a formulation that is pH and time dependent.\(^1\) Budesonide has markedly reduced systemic adverse effects compared with other corticosteroids, and budesonide trials have shown the drug to be more effective when concomitantly with mesalazine than when mesalazine is used alone. Furthermore, it has similar efficacy to prednisolone (a derivative of prednisone) for inducing remission of active Crohn disease. Prednisone, a more potent corticosteroid, is used primarily for patients who do not respond to sulfasalazine, mesalazine, or budesonide, or outpatients with severe disease.\(^1\) Prednisone itself is inactive until it is converted in the liver into prednisolone.

Caution must be used with these drugs. After approximately 7 days of corticosteroid use, the ability of the adrenal cortex to produce natural corticosteroids is suppressed, and the patient is at risk for steroid dependency. For this reason, as well as the various short-term and long-term adverse effects associated with the use of corticosteroids, prolonged use is not recommended. Instead, substitution with an immunosuppressive drug is the standard of care whenever possible.

**Immunomodulators**

Immunomodulatory agents, particularly immunosuppressors, often are used concomitantly with antibiotic and antiinflammatory therapy to down-regulate the body’s overactive immune response and prevent prolonged distribution of inflammatory cytokines. Classified as cytokine antagonists, drugs such as infliximab and adalimumab specifically target the production of tumor necrosis factor-alpha (TNF-\(\alpha\)). TNF-\(\alpha\) is a cytokine involved in systemic inflammation. An acute-phase protein, it belongs to a class of proteins whose plasma concentrations increase or decrease in response to inflammation. The primary role of TNF-\(\alpha\) is regulation of immune cells and induction of programmed cell death, thus initiating inflammation.\(^2\) Hence, the goal of using immunomodulation therapy is to block TNF-\(\alpha\) release and prevent apoptosis as well as subsequent activation of the inflammatory cascade.

Infliximab is a biological therapy drug, meaning that it is derived from living sources, specifically murine (mouse) protein. It is prescribed as a complementary drug for patients with moderate-to-severe Crohn disease in combination with an antiinflammatory medication.\(^1\) Administered as an infusion, infliximab acts as an antibody that binds to TNF-\(\alpha\) and neutralizes the cytokine. However, because infliximab must be given by infusion, and some patients might have difficulty with the infusion process, adalimumab can be prescribed as an alternative. An anti–TNF-\(\alpha\) antibody constructed similarly to infliximab, this drug differs only in that it consists of a fully human protein component and can be administered subcutaneously.

One other immunomodulatory drug that often is prescribed in combination with other TNF-\(\alpha\) suppressants is methotrexate. Methotrexate is a folate antimetabolite that is structurally related to folic acid and acts as an antagonist to the vitamin. By inhibiting dihydrofolate reductase—the enzyme that converts folic acid to its active form, tetrahydrofolic acid—methotrexate deprives lymphocyte cells of folate and leads to decreased production of the compounds that these cells depend on for replication. Inhibition of dihydrofolate reductase indirectly leads to depressed DNA, RNA, and protein synthesis, and ultimately cell death.\(^2\) Furthermore, methotrexate prolongs the efficacy of infliximab by preventing the development of antiinfliximab antibodies.

Through a combination of drug therapies, patients with Crohn disease should manage to reach a state of disease remission, a decrease in disease symptoms, and an increase in their quality of life. However, it is crucial to manage patients with a drug therapy protocol that will help them maintain their remission. Two structurally
related immunomodulatory drugs given to aid in the withdrawal of remission-inducing corticosteroids while maintaining disease remission are azathioprine and its analog, 6-mercaptopurine. Azathioprine exhibits its effects after it is converted into 6-mercaptopurine, in which it then penetrates target cells and is converted into the nucleotide TIMP1. TIMP1 then inhibits the biosynthesis of purine, resulting in decreased RNA and DNA production within lymphocytes and thus an overall decrease in lymphocyte production. Because of the delayed onset of treatment efficacy associated with remission-maintenance drugs, ranging from 6 to 17 weeks, they often are given in combination with the remission-inducing agents at the beginning of the remission maintenance protocol. Once the dedicated maintenance therapy is in full effect, the remission-inducing agents can be discontinued. However, the remission-maintenance therapy usually is continued for the remainder of the patient’s life.

Other Antibiotics

An additional treatment protocol is followed when managing a patient with complications related to the penetrating form of Crohn disease. The first line of therapy for these patients is antibiotic drugs such as ciprofloxacin and metronidazole, which are specifically used for their primary effects on the colonic and perianal enterobacteria. The goal is to prevent the bacteria that are native to the intestinal tract from traveling through the fistulous tracts that have developed and proliferating outside the GI system, where they are likely to induce sepsis. Ciprofloxacin, a second-generation fluoroquinolone, works by entering the bacterium by passive diffusion through water-filled protein channels in the outer cell membrane. Once inside the cell, ciprofloxacin inhibits the replication of bacterial DNA, and thus leads to bacterial cell death. Metronidazole has a different mechanism of action. Its metabolites break down into compounds that enter the bacterial cells, binding to intracellular macromolecules and inducing a bactericidal effect. When needed, the second line of treatment consists of the introduction of an immunosuppressant, either azathioprine or mercaptopurine, in combination with infliximab or adalimumab, assuming these drugs are not already prescribed as part of the primary Crohn disease treatment.

**Surgical Interventions**

More than 50% of patients with Crohn disease will require at least 1 surgical procedure during the course of their disease. Surgical intervention for the treatment of Crohn disease–related complications typically is reserved for patients who have not responded to pharmacologic therapies or are in an acute, life-threatening state, specifically those who have luminal strictures leading to bowel obstruction or fistulae complicated by abscess formation and significant blood loss.

**Bowel Resection**

The traditional surgical method used for fistulizing segments of bowel is resection of the affected segments of the GI tract, followed by anastomosis of the proximal and distal ends of the unaffected bowel. The rate of recurrence with bowel resection procedures is relatively high, with 70% of patients having an endoscopically confirmed recurrence within 1 year of surgery and 50% having a symptomatic recurrence within 4 years. Furthermore, patients who require a second resection surgery usually receive such treatment within 5 years, with the recurrence presenting at the previous site of anastomosis. Furthermore, scars related to bowel surgery can form adhesions and become a potential cause of bowel obstruction.

**Strictureplasty**

Another option for treating bowel obstruction is strictureplasty. This surgery restores free flow through the bowel without removing narrowed segments. Strictureplasty involves widening a narrowed segment of bowel lumen by making an incision lengthwise along 1 side of the bowel, pushing the 2 ends of the cut together, and then suturing the bowel transversely (see Figure 9). This process can be repeated at multiple sites of strictureing along the bowel in a single surgical session and can be particularly helpful for those who already have had extensive bowel resection and are at risk for short bowel syndrome.

**Surgical Complications and Postsurgical Care**

Short bowel syndrome, also known as short gut syndrome, is a malabsorption disorder that generally occurs with the removal of 50% or more of the intestinal tract, especially when the small intestine is involved. Short gut
Complementary and Alternative Treatments

Complementary and alternative medicine is defined as a group of diverse medical and health care systems, practices, and products that are not generally considered part of Western conventional medicine. Despite a lack of scientific data in the form of controlled trials for either the efficacy or safety of complementary and alternative medicine treatments, its use by patients with IBD is widespread and increasing. Several complementary and alternative medicine methods have been used specifically to treat symptoms related to Crohn disease. These treatment methods include probiotics and prebiotics, acupuncture, botanical extracts, smoking cessation education, stress reduction techniques, and diet modification.

Probiotics are living microbes commonly consumed as part of fermented foods with specially added active live cultures. Specific probiotic organisms include Lactobacilli, Bifidobacteria, gram-positive cocci, Enterococci, and yeast species such as Saccharomyces boulardii. Evidence from animal models of IBD suggests that probiotics can alter the intestinal microbiota and ameliorate disease, treating symptoms of flatulence, diarrhea, and abdominal pain. The suggested mechanism of action is related to their potential to improve immune function by protecting against pathogens by means of competitive inhibition.

Prebiotics differ from probiotics in that they are nondigestible food ingredients that stimulate the growth and activity of commensal bacteria in the digestive system that are beneficial to the body. Prebiotics most often are made up of soluble fiber, such as fermented short-chain carbohydrates, and allow specific changes in both composition and activity of the GI flora. Similar to probiotics, prebiotics can enhance luminal immunoregulatory bacteria, reduce the activity of proinflammatory factors, and decrease inflammation. However, when evaluated in human trials, neither pre- nor probiotics proved efficacious except in a few trials consisting of only a few subjects. Further research is required before this treatment method will be used routinely.

A second alternative therapy suggested for use in treating Crohn disease is acupuncture. Acupuncture involves inserting and manipulating needles into various points on the body to induce a controlled inflammatory response. It has been hypothesized that acupuncture potentially activates the body’s immune system, influencing nonspecific cellular influx, activation of cell proliferation, and regulation of subsequently involved cells, resulting in transport, breakdown, and clearance of bioactive mediators of inflammation. Although peer-reviewed research is limited, the data seem to indicate that acupuncture could contribute to recovery in patients with IBD.

Another alternative therapy for IBD patients being researched is the use of botanical extracts. The gum resin extract of Boswellia has been reported to have antiinflammatory and immunomodulatory activity, and Scutellaria’s active flavanoid compounds reportedly have potent antifibrotic effects. The use of natural products to aid in Crohn disease treatment is thought to reduce the risk of toxicity associated with pharmacologic treatment while maintaining the drugs’ therapeutic effectiveness. In addition, recent investigations into the role of...
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To the indigenous flora and other luminal antigens. An increase in the permeability of the intestinal epithelial layer allows pathogens to leak through with less resistance, and the mucosa’s inability to suppress an inappropriately triggered immune response compounds the pathogenic process.

Data suggest that those with first-degree family members who have the disease are predisposed to Crohn disease. Furthermore, individuals of Ashkenazi Jewish descent also are at an increased risk for developing Crohn disease. Geographic data indicate an increased risk of developing the disease for those living in the northern hemisphere, particularly the United States and Northern Europe.

The primary manifestations of the disease include intramural inflammatory lesions that can occur at any section of the GI tract, although more typically in the small and large intestine, as well as stricturing and abscess formation. These initial disease manifestations can lead to further complications such as stenotic bowel lumen with potential for intestinal obstruction as well as metaplastic cell changes that lead to cancer. Crohn disease can be misdiagnosed as ulcerative colitis; the presence of skip lesions, in which inflammatory lesions develop in more distal aspects of the bowel, usually helps differentiate between the 2 diseases. Because Crohn disease is a systemic autoimmune disease, there is potential for extraintestinal manifestations.

There is no gold standard for the diagnosis of Crohn disease. Instead, a combination of laboratory analysis, comprehensive patient history and physical examination, and various medical imaging examinations are used to confirm the disease and track its progression. Static radiographs and dynamic fluoroscopic imaging can aid in identifying bowel strictures, adhesions, fistulae, and obstructions. CT imaging, another method for assessing the entirety of the GI tract, often is used to differentiate between Crohn disease and appendicitis. However, radiation dose should be considered when serial imaging is required. MR imaging offers a radiation-free option and is especially useful for assessing the presence and extent of perianal disease, as well as for evaluating bowel wall thickening. The role of ultrasonography is limited primarily to evaluation of extraintestinal disease manifestations related to the gallbladder and liver. Endoscopic imaging, often performed with both an anterograde and...
and retrograde approach to visualize the entire GI tract, or via a pill camera, has largely taken precedence over radiographic imaging, although these approaches come with procedural risks.

Traditional treatments for Crohn disease primarily depend on pharmacologic therapies, with surgical intervention being used when necessary. Decisions regarding which drugs to prescribe are determined based on the stage of the disease, level of disease activity, and evidence of penetrating behavior. A regimen of various antibiotics, corticosteroids, immunomodulatory drugs, and antiinflammatory medications can be prescribed to help bring the disease into a state of remission and prevent future flare-ups. However, no cure for Crohn disease currently is available. Surgical intervention for the treatment of Crohn-related complications typically is reserved for patients who have not responded to pharmacologic therapies or who are in an acute, life-threatening state. Commonly, surgery consists of resection of the diseased bowel with an anastomosis of the 2 remaining bowel ends. Complementary and alternative medical approaches also are used as part of the treatment plan and consist of acupuncture, pre- and probiotics, botanical extracts, and dietary restrictions.

Jonathan Mazal, MS, R.R.A., R.T.(R)(MR), has published works in both commercial and peer-reviewed literature, in addition to editing projects that include medical textbooks and continuing education articles. He is a certified radiologist assistant and has a bachelor’s and master’s degree in radiologic sciences from The Ohio State University in Columbus. Mazal is a 2010 Siemens Clinical Advancement Scholarship recipient. He was recognized at the 2011 Virtual Symposium on Research in the Advancing Researcher category for “Comparative Effectiveness of Alternative Imaging Procedures in Monitoring the Progression of Crohn’s Disease.” He is also a member of the Radiologic Technology Editorial Review Board.

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References


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1. The human intestine harbors the largest and most diverse collection of microbial flora within the body, consisting of more than _______ species of commensal bacteria.
   a. 50
   b. 100
   c. 500
   d. 1000

2. To maintain a healthy relationship between the intestinal mucosa and its natural flora, immune homeostasis depends on 3 key mucosal functions.
   a. true
   b. false

3. Results of increased access of microbial pathogens to the submucosa's numerous embedded antigen receptors include:
   1. triggering of an immune response.
   2. initiating the inflammatory cascade.
   3. suppressing the immune response.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

4. Data has shown that for an individual of _______ descent with a first-degree relative who has Crohn disease, the estimated lifetime risk of developing Crohn disease increases to 7.8%.
   a. Native American
   b. Middle Eastern Jewish (Sephardi)
   c. European Jewish (Ashkenazi)
   d. Asian

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5. For a person with a mutation in one of the inflammatory bowel disease (IBD) gene loci, the relative risk of developing the disease is approximately:
   a. 1:5.
   b. 1:50.
   c. 1:100.
   d. 1:200.

6. Which global hemisphere has the highest reported incidence rates and prevalence of Crohn disease cases?
   a. northern
   b. southern
   c. eastern
   d. western

7. The Vienna classification was developed to describe the distinct clinical phenotypes of Crohn disease with respect to:
   1. disease location.
   2. potential complications.
   3. duration of symptoms.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

8. When there is narrowing of the intestinal lumen, patients with Crohn disease are in danger of developing a(n) ______, a complication of the disease in which the intestinal pathway becomes occluded.
   a. hiatal hernia
   b. ileus
   c. mechanical intestinal obstruction
   d. intestinal perforation

9. One manifestation of Crohn disease is a transmural pattern of inflammation, with evidence of inflammation spanning ______ of the intestinal wall.
   a. through the mucosal layer
   b. slightly into the submucosal layer
   c. through the muscular layer
   d. the entire depth

10. Which of the following is not a potential comorbidity associated with Crohn disease?
    a. migratory polyarthritis
    b. pericarditis
    c. sclerosing cholangitis
    d. ankylosing spondylitis

11. Which Crohn disease course is most common?
    a. chronic intermittent
    b. chronic active
    c. remission for several years at a time
    d. complete recovery

12. Race has been shown to play a role in the development of Crohn disease in North America, with prevalence rates for Hispanics and Asians being ______ compared with rates for whites and African Americans.
    a. similar
    b. much lower
    c. slightly higher
    d. much higher

13. The administration of the attenuated live measles, mumps, and rubella vaccine is hypothesized to ______ the risk of IBD.
    a. decrease
    b. increase
    c. both increase and decrease
    d. have no effect on

continued on next page
14. Approximately ______ of patients who have Crohn disease with either large or small bowel involvement exhibit signs of perianal disease.
   a. two-thirds  
   b. one-half  
   c. one-third  
   d. one-quarter

15. Laboratory tests that can confirm the presence of nonspecific inflammatory activity include:
   1. erythrocyte sedimentary rate.
   2. C-reactive protein.
   3. leukocyte and platelet counts.
   a. 1 and 2  
   b. 1 and 3  
   c. 2 and 3  
   d. 1, 2, and 3

16. Enteroclysis is a technique in which contrast material is introduced rapidly into the intestinal tract below the ______ junction.
   a. gastroesophageal  
   b. gastroduodenal  
   c. duodenojejunal  
   d. ileocecal

17. Which of the following are benefits of magnetic resonance imaging over computed tomography for patients with Crohn disease?
   1. characterizing perirectal abscesses and fistulae
   2. it is a radiation-free exam
   3. ability to differentiate between peristalsis and skip lesions
   a. 1 and 2  
   b. 1 and 3  
   c. 2 and 3  
   d. 1, 2, and 3

18. Medications are prescribed to patients who have Crohn disease based on:
   1. stage of disease process.
   2. level of disease activity.
   3. evidence of penetrating behavior.
   a. 1 and 2  
   b. 1 and 3  
   c. 2 and 3  
   d. 1, 2, and 3

19. Which medication typically is prescribed in place of sulfasalazine for patients with sulfa-related intolerance?
   a. corticosteroids  
   b. arachidonic acid  
   c. mesalazine  
   d. methotrexate

20. The goal of immunomodulation therapy is to ______ TNF-α release and ______ apoptosis as well as subsequent activation of the inflammatory cascade.
   a. block; prevent  
   b. activate; permit  
   c. block; permit  
   d. activate; prevent

21. ______ prolongs the efficacy of infliximab by preventing the development of antiinfliximab antibodies.
   a. Mesalazine  
   b. Arachidonic acid  
   c. Corticosteroids  
   d. Methotrexate

continued on next page
22. More than ______ % of patients with Crohn disease will require at least 1 surgical procedure during the course of their disease.
   a. 10  
   b. 25  
   c. 50  
   d. 75

23. Which surgical procedure involves widening a narrowed segment of bowel lumen by making an incision lengthwise along 1 side of the bowel, pushing the 2 ends of the cut together, and then suturing the bowel transversely?
   a. Whipple procedure  
   b. stricturoplasty  
   c. bowel resection  
   d. bowel diversion

24. Which of the following complementary and alternative medicine–related treatments is not specifically used to treat patients with Crohn disease?
   a. prebiotics and probiotics  
   b. acupuncture  
   c. raw foods diet  
   d. botanical extracts

25. Which of the following does not seem to increase the likelihood of relapse in patients with disease remission?
   a. adverse life events  
   b. chronic stress  
   c. depression  
   d. extended hunger
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Crohn Disease

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   ○ Not beneficial

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   ○ Just the right level
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   ○ Too easy

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   ○ Somewhat short
   ○ Too short

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   ○ No

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   ○ Valuable
   ○ Somewhat valuable
   ○ Not very valuable

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This advanced text is part of a series from Springer Reference called Evidence-Based Imaging: Improving Quality in Patient Care. An earlier text provided a general overview of research-supported considerations for medical imaging, and another volume addressed pediatric imaging. In this most recent release, the editors make a strong argument in support of evidence-based decision making for neuroimaging. In light of the current economics of health care and as the deleterious effects of medical radiation exposure continue to be a major concern, the editors propose that this text could help counter the overuse of imaging in an era of “defensive medicine.”

This in-depth exploration into the complexities of neuroimaging is not for the casual reader. The well-organized, well-researched text is best suited for the physician or other advanced practitioner involved in ordering imaging evaluation of neurologic pathology.

However, imaging technologists might find the information in the introductory chapters helpful, specifically the chapter that reviews current issues surrounding the risks of medical radiation exposure and intravenous contrast administration in computed tomography and magnetic resonance (MR) imaging. Another helpful section covers the concept and process of evidence-based imaging, which a number of contributing authors apply to clinical issues specifically related to neuroimaging.

The book outlines evidence-based imaging as a series of steps. The first step is to clarify the clinical question at hand. The next step is to gather the best and most current evidence from the medical literature and provide the reader a detailed analysis of the types of studies typically found. The text touches on inherent error and bias as well as the strengths and weaknesses that might be encountered when reading various publications. The final step of the evidence-based decision-making algorithm is synthesisation of the information into an appropriate clinical decision.

The book, with more than 30 chapters, outlines the imaging management questions medical practitioners routinely encounter. These clinical issues are organized into sections for the brain, the spine, and the head and neck. The evidence-based neuroimaging approach is reviewed for many key pathologic conditions, including stroke, traumatic brain injury, low-back pain, and sinusitis. Several chapters explore the effect of neuroimaging on less frequently addressed conditions such
as sickle cell disease, attention deficit hyperactivity disorder, and autism. Each chapter is organized to suit the needs of both the practicing clinician who wants a quick and to-the-point reference, as well as the researcher looking for a more in-depth analysis of the supporting evidence. The list of key points at the beginning of each chapter provides an efficient overview, followed by a thorough description of each area of pathology and a summary of a statistical analysis of the disease prevalence and distribution. The financial effect of disease epidemiology and treatment also is addressed, as well as the cost associated with medical imaging.

Each chapter features issues that focus on current evidence to help practitioners make informed decisions that lead to the best possible outcomes for their patients. The most appropriate imaging modalities and treatment options for each pathologic condition are identified, supported by references to the latest research articles. The authors also provide suggested imaging protocols for each anatomic area or pathologic condition, which might interest technologists who want to take an active role in an evidence-based approach to neuroimaging.

Daniel N DeMaio, MEd, R.T.(R)(CT)
Director, Radiologic Technology Program
University of Hartford
West Hartford, Connecticut


Anatomy: An Essential Textbook is a valuable resource for first-year students in any medical field. Anne Gilroy prepared this book in response to increased demand on students’ time and changing learning styles, creating a concise text that offers clinical context, rapid review, and self-testing. More than 450 full-color illustrations allow students to visualize detailed anatomical structures of all body systems. Gilroy provides clear definitions and functions of human anatomy, while tables summarize important information. Each major section is followed by United States Medical Licensing Examination–styled questions that test comprehension. Correct answers and explanations are provided after each quiz, which includes questions that test clinical application of the material.

Using the access code that comes with the book, readers can create an account at the companion Web site to access online content such as the quiz questions from the book as well as additional questions, all with automatic grading. The account also provides access to the Atlas of Anatomy database of images. This database of 500 illustrations of human anatomy features a labels on/labels off function that allows readers to test themselves in identifying specific structures. Also included are radiologic images for most sections of anatomy, including radiographs, MR images, intravenous contrast studies, and angiograms. Setting up the online account is easy, and “Quick Tips” in the menu at the top of the page provides brief instructions.

Readers who use the online content can test themselves on more specific content areas such as obstetrics and gynecology, medical physiology, and pharmacology. Thieme publishes other textbooks in these areas and offers a sampling of the questions associated with them to readers with an access code. Subscriptions to the “pro” version of the Web site range from $30 to $60 for 1 to 6 months, and a “24-Hour Panic Package” is available for $24. The pro version also offers more than 1800 images and clinical material including MR images and computed tomography scans.

At less than $50, this comprehensive text and its online content are great values that instructors and students alike will appreciate and want to keep handy for quick review.

Lisa Ragsdale, MA
Academic Editor
American Society of Radiologic Technologists
Albuquerque, New Mexico
This book is exactly as described: “better suited for any clinician who uses MRI perfusion in their clinical practice, as well as to researchers in the field of MRI.” Once MR imaging perfusion becomes more routine and available, this book might be considered the authority on MR imaging perfusion, but most technologists and radiologists will have little use for it now.

Nancy Kotinek Chiczewski, R.T.(R)(CT)(MR)(BD), EMT
Chief Technologist
KSF Orthopaedic Center
Houston, Texas

A Death Retold: Jesica Santillan, the Bungled Transplant, and Paradoxes of Medical Citizenship.

As the U.S. government explores new health care initiatives and the country debates the emotional issue of immigration, A Death Retold is a tale for the times. In 2003, Jesica Santillan, a 17-year-old Mexican immigrant living illegally in the United States, received a heart-lung transplant at Duke University Medical Center in North Carolina. The prestigious hospital had a system failure and gave Santillan organs matching blood type A even though she was type O.

Two fatal assumptions led to the error. The first patient on the transplant list was not transplantable the night the organs became available, and Dr James Jaggers, head of pediatric heart and heart-lung transplantation at Duke, wrongly assumed that the organs were offered to Santillan because there was a blood match. The second assumption was from the local organ procurement organization, which assumed that Jaggers was aware of the incompatible blood type and that the patient had undergone treatment to accept the organs—a viable option if the patient’s survival is in question.
Santillan received the heart-lung transplant because she was diagnosed with restrictive cardiomyopathy, a stiffening of the heart walls that creates poor blood flow and ultimately results in heart failure. At the time of her transplant, she was already considered beyond the 3- to 5-year life expectancy of this fatal condition.

Jaggers learned of the blood type error from the Duke blood bank after the perfectly performed procedure was completed. (Duke said the operation was error-free and objected to the procedure being called a “bungled transplant.”) In rare cases, blood type O works immunologically for patients with a subtype of blood type A, but that was not the case with Santillan. After realizing the mistake, the medical team used a common technique called plasmapheresis, which removes plasma where antibodies reside and replaces it with donor plasma to reduce the antibody levels. Unfortunately, it was too late for the procedure to be successful. Two weeks later, Santillan underwent a second transplant, but it failed to save her life.

Out of this controversy arose a series of discussions by a variety of experts in medical ethics, sociology, transplants, immigration studies, and health law, among other areas. These leaders in their fields contributed essays that became this book.

The first section, Medical Error and the American Transplant Theater, follows the media coverage and influence on the case. The way Santillan and her family were portrayed—initially with sympathy and later as thieves of organs that could have helped citizens—flamed the fire of prejudice against immigrants. Transplants are expensive and complex, and as a medical option, they are wrought with misconceptions. People fear organs are being “harvested” from unsuspecting victims and sold on the black market, that the wealthiest people get the best organs first, and that doctors will not try to save organ donors’ lives if they are hospitalized. Society’s mixed emotions concerning organ donation and how the public views modern medicine and the human body were influenced by the publicity of this compelling story.

Part 2, Justice and Second Chances Across the Border, covers how the second transplant attempt heightened the public discourse with questions about deservedness and wastefulness. A second, third, and even fourth transplant in patients with failing organs is common, but heart-lung transplants are rare—only about 100 are performed each year in the United States because of a lack of suitable donors. The Santillan family crossed illegally into this country in 1999 knowing their daughter needed medical care best found here. The United Network for Organ Sharing, which manages the organ transplant system in the United States, allows noncitizens to receive up to 5% of available organs. Medicaid specifically excludes organ transplants, as they are not considered acute care.

The third section, Citizens and Foreigners/ Eligibility and Exclusion, is composed of essays examining the unusual aspects of Santillan’s case. Santillan’s mother had health insurance through her employer, and thousands of dollars had been raised for the transplant by a private organization and donations. Some Americans responded with charity, and others defended what they believed should be citizens’ benefits alone.

The book concludes with “Speaking for Jesica,” a chapter that asks what the person at the center of the controversy might have said had she been older, a U.S. citizen, and able to be more involved. No right or wrong answers are presented in A Death Retold, but the writings offer important considerations for longer discussions among health care workers and laypeople alike.

Cristina Olds, BA
Writer, graphic designer, and teacher
Olds Creative
Albuquerque, New Mexico
Translational research affords many opportunities for the advancement of radiologic sciences and growth in the profession’s body of knowledge. Understanding translational research requires having clear definitions of the types of investigation involved with this classification of research. Basic or “traditional” research typically is thought of as laboratory or bench-top research that involves experimentation that advances general knowledge of a subject. Clinical research involves human subjects, as in clinical trials, epidemiological and behavioral studies, or outcomes and health services research. Rubio et al define translational research as an integration of basic and clinical research to improve patients’ overall health and well-being. They further categorize their definition into 3 parts. The first part, T1, is the process that connects bench-top research to bedside and is the classification that applies here. T2 involves connections between patient-oriented and population-based research, and T3 connects lab-based to population-based research.

Opportunities in the Radiologic Sciences

Radiologic science practitioners, educators, and researchers often generate ideas for improving the profession. Engaging in translational research provides connections within the profession to study, apply, and put into practice these ideas within a shorter timeframe than the traditional research process. Translational research does not circumvent good research; rather, it shortens the time to clinical application. Many professionals are not comfortable with research because they lack formal training in the processes, but they have great ideas that would improve the quality of patient care. Some are well trained in research methodology but lack connections to practical settings in which to test new theories and discoveries. Translational research bridges the gap between these 2 groups.

The following examples of the types of data used in this research demonstrate how translational research can benefit the radiologic sciences.

Procedural Data

Procedural data are those collected for patient, procedural, or quality control purposes and not necessarily with a research question in mind. Because the data are not collected to answer a specific research question, the information might not lend itself to the analysis necessary to provide the desired answers. Even so, much can be done with these data.

For example, a department might notice a periodic patient complication during certain magnetic resonance imaging procedures. The procedural data collected includes demographic information (eg, height, weight, age, race, and sex) as well as medical history (eg, allergies, medications prescribed and used, and chronic diseases) of those experiencing the hypothetical procedural complication in this example. In the hands of a researcher, these data could be analyzed for correlations...
between factors or significant differences in incidence of the complication to identify the cause. The procedure or protocol then could be modified to avoid the complication. Such a direct link between technologist and researcher could cut months or years off the time it takes to discover the complication’s cause and provide a quick solution to the problem. Publishing the research shares the discovery with the medical community as a whole.

In another example, a radiologic technologist noticed a high repeat rate for examinations that required the scapula to be in a lateral position. The technologist identified and then perfected in the laboratory new landmarks for such positions. Through connections with the department’s clinical sites and with institutional review board approval, these landmarks were tested in the clinical setting and adopted. The work was published and later referenced in a major positioning textbook. In contrast to the traditional research process, this translational research method had a faster “bench-top to bedside” dissemination in a number of clinical settings, and it was possible to reduce repeat exposures and patient radiation dose before mainstream publication widely disseminated the results.

Archival Data
Archival data typically are more focused than procedural data and might not have been collected for research purposes. Sometimes data are collected for research and then stored in a database for future analysis. This is common when a large grant-funded study is conducted to collect more data while the opportunity exists than is actually needed. Archival data also might have been collected for assessment purposes and, like procedural data, is useful for research.

Some radiologic science educators, for example, express concerns about the effectiveness of online instruction in entry-level radiography programs, and discussions continue about what should and should not be taught online. Student data maintained for assessment and program accreditation purposes such as grade point average, course grades, and American Registry of Radiologic Technologists examination pass rates were used to compare student performance in online vs face-to-face versions of 2 entry-level radiography courses. The results were presented as live lectures to the radiologic science education community in a variety of venues to help make decisions about the use of online instruction, but the results also had broader interest and were published. Rather than waiting for the research to be investigated in a traditional fashion and then applied, this translational research method offered a more immediate effect on radiologic science educational practice.

Role of Practitioners and Researchers
The relationship between researcher and practitioner is mutually beneficial. Clinical practitioners can provide many research ideas and opportunities by being aware of clinical practice trends and problems and generating ideas for innovative approaches to daily tasks. Clinical practitioners also can relay these ideas to a researcher to aid in bringing them to fruition. The other role of the practitioner is to partner with a researcher in an implementation or clinical trial phase of a project. The practitioner’s participation and feedback are crucial in the translational research process.

Researchers are experts in research design, methodology, data collection, and analysis, and they should be willing to lend expertise to the clinical practice area. However, researchers also should be generating ideas and opportunities to advance knowledge and improve areas of medical imaging. Often the researcher has the laboratory or research tools to test theories and develop proof of concepts before moving the research to a clinical setting. Once obtained, laboratory and other research results should be implemented in clinical practice as quickly as possible for the benefit of all.

Researchers should be receptive to ideas and aware of problems in the clinical environment and work with clinical practitioners to identify solutions. If approached to help in this way, the researcher can apply a research design or method, formalizing the process and systematically testing possible solutions.

Establishing Partnerships
The success of translational research depends on the partnerships between research institutions and clinical settings, the bench top and bedside of T1 translational research. Radiologic science educational programs and clinical settings already partner to provide clinical training for students. When both
partners recognize opportunities and communicate with each other, they can create a cooperative translational research environment.

James Johnston, PhD, R.T.(R)(CV), FASRT, is an associate professor of radiologic sciences and dean of the Robert D and Carol Gunn College of Health Sciences and Human Services at Midwestern State University in Wichita Falls, Texas. He is the vice chairman of the Radiologic Technology Editorial Review Board. He can be reached at james.johnston@mwsu.edu.

References
Inside the JRCERT

Stephanie Eatmon, EdD, R.T.(R)(T), FASRT

If a request for additional or clarifying information from the Joint Review Committee on Education in Radiologic Technology (JRCERT) following a site visit or an interim report ever left you wondering more about this organization, this article should help.

The Mission

The vision statement for the JRCERT is “Excellence in Education,” and this statement is the driving force behind every action the committee takes. Its mission statement takes this idea one step further, stating that the JRCERT:

- Promotes excellence in education and elevates the quality and safety of patient care through the accreditation of educational programs in radiography, radiation therapy, magnetic resonance, and medical dosimetry.

This statement guides the people who make up the JRCERT, including the board of directors, chief executive officer, staff, and volunteer site visitors. Each of these people is passionate about educational quality and the resulting quality and safety of patient care (see Box).

The Members

The JRCERT professional staff includes 6 individuals who have experience as program directors of radiologic science programs. Prior to joining the JRCERT, they were responsible for ensuring their programs adhered to the JRCERT Standards and maintained accreditation.

Box

**Joint Review Committee on Education in Radiologic Technology Core Values**

- Maintains recognition by the United States Department of Education and the Council for Higher Education Accreditation as the only programmatic accreditor for radiologic sciences programs.
- Believes educational quality and integrity cannot be compromised.
- Respects the rights and promotes the welfare of students and patients.
- Appreciates that the programs it serves utilize diverse approaches to quality education.
- Collaborates with other organizations to advance professionalism.
- Exemplifies the highest ethical principles in its actions and decisions.
- Is responsive to the changing needs of the profession.

The seventh professional staff member was a radiologic administrator and adjunct instructor who is passionate about education and patient care.

The JRCERT Board of Directors consists of 5 current program directors representing radiography, radiation therapy, and medical dosimetry programs. In addition, the board includes one radiologist, one imaging department administrator, and a university professor who specializes in outcomes assessment and serves the Higher Learning Commission in a special capacity. Each
member of the JRCERT professional staff and board of directors is an active professional dedicated to ensuring excellence in education.

**Accrediting the JRCERT**

The JRCERT is the only agency recognized by the U.S. Department of Education and the Council for Higher Education Accreditation for the accreditation of traditional and distance delivery educational programs in radiography, radiation therapy, magnetic resonance, and medical dosimetry. Many of the requirements for programmatic accreditation are the result of the JRCERT fulfilling requirements to maintain accrediting agency recognition. Just as educational programs must meet the JRCERT Standards to achieve accreditation, the JRCERT needs to meet requirements of its own.

**How Decisions Are Made**

Once program information is submitted to the JRCERT office, a member of the professional staff reviews the documentation in relation to the JRCERT Standards. If he or she finds that information is missing or needs modification, the staff member contacts the program director and requests additional or clarifying information to complete the documentation before the materials go to the JRCERT Board of Directors.

Once the program information goes to the board, each director reads and reviews the information submitted. Board members recuse themselves from programs within their state and any others in which they feel there could be a conflict of interest. The board thoroughly discusses each program at the monthly board meeting and renders an accreditation decision, taking great care to be fair and consistent in its decisions regarding accreditation.

**Compliance Resources**

Ideally, every program would be in full compliance with the JRCERT Standards at all times, but this is not always realistic. When the committee identifies noncompliance issues, programs receive appropriate guidance for taking corrective actions to demonstrate compliance. The JRCERT is committed to providing education to assist radiologic science programs in gaining and maintaining programmatic accreditation. This education includes seminars, workshops, online modules, and checklists that offer guidance about documenting compliance with the relevant JRCERT Standards.

The JRCERT wants to work collaboratively with programs to ensure academic quality, and its staff members are more than willing to help.

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Stephanie Eatmon, EdD, R.T.(R)(T), FASRT, is a member of the advisory board for the Grand Valley State University medical dosimetry program and a member of the JRCERT Board of Directors. She can be contacted at stephanie.eatmon@csulb.edu.

**Reference**


To learn more about the JRCERT, visit www.jrcert.org.
The Portability of Hospital-Acquired Infections

Sharon Kathleen Jacoby, R.T.(R)
Catherine De Angelis, R.T.(R)

Nosocomial infections are hospital-acquired infections (HAIs), also known as healthcare-associated infections, caused by cross-contamination of pathogens or bioburden (bacteria on unsterilized surfaces). These infections usually are spread by hospital personnel. Patient guests usually are not informed about decontamination methods; thus, they have been eliminated from most surveys. Almost 2 million HAIs occur in the United States every year, costing hospitals about $45 billion dollars. In 2009, Medicare and Medicaid stopped reimbursing hospitals for the treatment of HAIs in Medicare patients, making infection control an even greater priority for hospitals.1 Many articles describe the need for cleaning equipment regularly but few have published suitable methods for testing whether the process is effective.

The 2010 National and State Healthcare-Associated Infections Standardized Infection Ratio Report published by the Centers for Disease Control and Prevention stated that 22 states and Washington, DC, require or have plans to require mandatory infectious disease reporting.2 However, even if a state does not require mandatory reporting now, testing for the major transmissible pathogens such as methicillin-resistant Staphylococcus aureus (MRSA) and vancomycin-resistant Enterococci is routine in most health facilities (see Box 1). Specific pathogen testing usually takes 5 to 10 days because of incubation time; therefore, this testing usually is not performed. Mycobacteria test results can take 6 weeks.3-9

Portable x-ray machines can be mechanisms for transporting bacteria and viruses to the entire hospital campus. HAIs usually are spread by complacent personnel and indirect contact transmission. Cleaning the equipment is paramount, and this means cleaning correctly and with the right agent. In addition, technologists should be aware of suitable testing methods to ensure the equipment is clean.

New portable x-ray equipment brings with it the expected complexities of cutting-edge technology, but it also could require a cleaning validation. A cleaning validation requires establishing a cleaning regimen with checks and balances to ensure proper, regular cleaning. When we obtained new portable x-ray equipment at the Mayo Clinic in Florida, we questioned what components needed cleaning, how often cleaning should occur, and what cleaning agent would be suitable. All facilities and equipment manufacturers have a user directory for recommended cleaning products; however, some products might not be adequate to eradicate new superbugs such as MRSA, and electronic equipment could be sensitive to harsh cleaning agents. The machine’s disposable image receptor cover prevents cross-contamination; however, we found that no suitable nondestructive cleaning agent was available for the exposure button, viewing screen, and laser lights.

The goals of our study were to:
- Prevent harm to patients and staff by reducing bioburden or pathogen transfer while using portable x-ray equipment.
Case Summary

The team proposed the following questions:

- What surfaces are directly related to the patient?
- What are the dangers of cross-contamination in our work?
- What is our cleaning protocol?
- Does the cleaning product or cleaning technique play a part in HAIs?
- Do touchable surfaces not involving the patient’s exam play a part in HAIs?
- What is the cost of HAIs in hospitals?

The infection control nurse acted as an independent observer and identified the areas a technologist would touch during a typical portable examination. We called these touch points. After several observations with different technologists, a list of touch points was established (see Box 2).

Our established protective procedure was to sanitize and glove hands, cover the image receptor with a disposable protective cover, and clean the equipment using CaviCide (Metrex), a hospital-wide disinfectant, before and after each portable examination. CaviCide is a low-alcohol disinfectant that kills Mycobacterium tuberculosis as well as MRSA. CaviCide was used to wipe the image surfaces in the touch points.

Methods

The project began with General Electric Healthcare portable x-ray equipment and is continuing with the new Carestream Health Inc equipment purchased as a replacement. A cordless phone carried from the department to other areas of the hospital also was tested. A team was organized to confirm that environmental hygiene on noncritical services was adequate and that communicable pathogens were not crossing over to patients. The team included the radiology department supervisor, an infection control nurse, a clinical instructor for the radiography program, and the coordinator for the physician resident program.

Box 1

Facts About Infectious Disease From the Centers for Disease Control and Prevention (CDC)

- HIV does not survive well outside the body, so environmental transmission is unlikely. However, HIV can live for up to 36 days in a syringe, depending on the type of syringe and the amount of virus it contains.¹
- The hepatitis C virus can remain viable outside the body at room temperature on surfaces from 16 hours to 4 days.⁴
- The hepatitis B virus can survive outside the body for at least a week.⁵
- *Clostridium difficile* (C. diff) spores are in a dormant, highly protected state and extremely resistant to heat, drying, and many chemical agents, including a variety of disinfectants. They can survive for up to 5 months on surfaces.⁶
- Vegetative (actively growing and in the disease-causing stage) cells of C. diff are susceptible to heat, drying, and disinfectants. Because they cannot tolerate oxygen, vegetative C. diff cells can live for only a few hours on surfaces.¹⁰
- Methicillin-resistant *Staphylococcus aureus* (MRSA) is a bacteria resistant to certain antibiotics called beta-lactams. The nose is the most common site of infection.⁷
- Vancomycin-resistant *Enterococci* are resistant to the antibiotic vancomycin and are part of the normal flora of the gastrointestinal tract. These bacteria can cause serious infections in the urinary tract, blood, or surgical wounds and typically occur in immunocompromised individuals in a hospital setting.⁸
- Carbapenem-resistant *Enterobacteriaceae* (CRE) is a dangerous bacteria causing an increasing number of hospital-acquired infections. CRE is resistant to nearly all antibiotics, and 50% of patients whose bloodstream become infected die. Nearly all CRE infections occur in patients who are receiving medical care, and the bacteria are transmitted from person to person. The CDC offers a CRE prevention toolkit with recommendations for health care facilities.⁹
Case Summary

The Portability of Hospital-Acquired Infections

Box 2

**Touch Points**

- Exposure switch with cord.
- Exposure switch without cord.
- Screens.
- Image receptor and battery.
- Tube adjustment handle.
- Push handle.
- Cordless phone.

receptor, the push handle, and the tube handle after every patient. The GE and Carestream x-ray machine manufacturer instructions indicated that the portable viewing screen and the electronic exposure switch could not be sanitized with any known product because a liquid agent would saturate the components and damage them.

Using a Clean-Trace NG Luminometer (3M), we swabbed equipment to test for the presence of adenosine triphosphate, which is found in all living cells. The luminometer measures relative light units (RLUs), which signify the amount of bioburden or pathogens living on a surface (see **Figure 1**). The base RLU number for bioburden-safe equipment was determined by the team to be fewer than 500 RLU for noncritical surfaces. If the unit touches the patient directly, then the acceptable bioburden is 250 RLU.

The team evaluated a variety of cleaning methods for the exposure switch and screen:

- Covering the switch with a sheath before touching.
- Double-gloving and then removing one glove to press the exposure switch and regloving to touch the patient.
- Cleaning the switch daily with 10% bleach and a porous towel.
- Using a washable screen protector (NuShield).

We chose to use the washable screen protector, and the staff alternated between double-gloving and regloving before touching the exposure switch.

To determine best practices, we investigated theories such as the benefits of cleaning nonwashable areas (eg, electronic exposure switch). We noted high-frequency noncritical touch points by observing a random sample of staff acquiring portable studies. Noncritical touch points are points on objects that do not come in direct contact with a patient. We also obtained manufacturer cleaning suggestions (see **Box 3**). Surfaces were swabbed and tested for bioburden to determine a baseline. We implemented staff education on methods of cleaning and then retested for bioburden. Behavioral competency was reinforced and maintained through individual accountability and attention to detail with the goal of retaining best practices and reducing bioburden on equipment surfaces.

**Results**

The RLUs recorded after we implemented our cleaning procedure were reduced on all noncritical touch points (see **Table**). We also found that even when equipment is not used regularly, it could become a reservoir for bioburden.

A protective cover had been installed on the cordless phone, and staff was instructed to clean the phone...
after each portable examination whether it was used or not. The baseline RLU value was 1164, and we hypothesized that the cover had been damaged from repeated cleaning. To evaluate this idea, the phone was swabbed, cleaned, and then swabbed again, revealing RLUs below 250. We interviewed staff members about their practices and discovered that the phone was not being cleaned if it was not used during the portable examination; however, it was being carried from the department to the portable examination and back several times a day by a number of staff members. Once the staff was aware of this oversight, the phone was cleaned after each trip.

The portable x-ray machine, although new, began to show areas of deterioration within 2 months. We contacted Carestream about the machine’s warranties and were assured that proper revitalization is covered if the manufacturer’s recommended cleaning suggestions are followed.

We purchased a holder for the bleach wipes and attached it to the portable equipment (see Figure 2). Bleach is necessary to kill C diff and is safe to use on stainless steel, glass, and plastic. We found it necessary to inform personnel that the cleaning solution could damage clothing. In one instance, bleach from the cleanser discolored a technologist’s uniform after she leaned on cleaned equipment that was still drying.

**Conclusion**

For several years we have focused on lowering infection rates and changing processes to make our care the safest possible. Our hospital’s efforts have earned an “A” for patient safety from the Leapfrog Group, an independent national nonprofit organization run by employers and other large purchasers of health benefits. The Leapfrog Hospital Safety Score uses 26 measures of

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**Box 3**

**Portable Machine Cleaners**

The following cleaners have been tested and approved for use by Carestream Health Inc:

- 70% isopropyl alcohol.
- 10% bleach solution (dilute 1 part 5.25% sodium hypochlorite with 9 parts water).
- Mild soapsuds.
- Kodak Intensifying Screen Cleaner and Antistatic Solution (Carestream Health Inc).
- Misty Multipurpose Disinfectant Cleaner (Amrep Inc).
- Misty Disinfectant and Deodorant RTU (Amrep Inc).
- Virex II 256 (Johnson Professional).
- Precise Hospital Foam Cleaner Disinfectant (Caltech Industries Inc).
- 1608-G4 surface wipes (STERIS Corporation).

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**Table**

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<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: N/A, not applicable; RLUs, relative light units.

**Figure 2**

Bleach wipes to clean portable x-ray equipment.
publicly available hospital safety data to produce a single score representing a hospital’s overall capacity to keep patients safe from infections, injuries, and medical and medication errors.

Staff awareness, easily accessible disposable wipes located on the portable x-ray machine, and quarterly testing for bioburden have helped our team significantly reduce the number of HAIs at our hospital.

Sharon Kathleen Jacoby, R.T.(R), is a clinical instructor for the radiology program at the Mayo Clinic in Jacksonville, Florida. She has contributed several articles to Radiologic Technology and has presented in other educational venues. She can be reached at jaco by.sharon@mayo.edu.

Catherine De Angelis, R.T.(R), is the supervisor of the diagnostic department at the Mayo Clinic in Jacksonville and participates in institution-wide quality projects. She has a background in interventional radiography, computed tomography, magnetic resonance, pediatric imaging, and medical sales. She can be reached at deangelis.catherine@mayo.edu.

References
The pelvis consists of the sacrum and 2 coxae. The coxae each are formed by the fusion of the ilium, the ischium, and the pubis. Portions of the 3 bones join to create the acetabulum, which is the socket of the ball-and-socket joint of the hip. The femoral head articulates with the pelvis at the acetabulum. The femur, while not part of the pelvic girdle, is important in pelvic imaging.

Near the femoral neck are 2 tuberosities, or trochanters. The greater trochanter is the large prominence located superiorly and laterally to the femoral shaft (see Figure 1). The lesser trochanter is the prominence located inferiorly and medially to the shaft. The anteroposterior (AP) projection of the pelvis ideally includes the pelvic girdle from the top of the ilium to the lesser trochanters of the femur from top to bottom and the greater trochanters on both sides from side to side.

Quality AP pelvis images can be difficult to replicate from patient to patient because of the difficulty in palpating typical landmarks during positioning. The most common palpable landmarks for a pelvis are the anterior superior iliac spine (ASIS) and the iliac crest. Finding these landmarks is equally difficult on patients with body types that are hypersthenic (excessively muscular) as well as hyposthenic (lacking muscle tone). Tall, slender men, for example, typically have long pelvic wings that are less flared, making iliac crest palpation difficult. Finding the ASIS generally is not as difficult, but the distance to the femoral neck or to the top of the ilium often is underestimated.

Schools teach 2 main positioning techniques for achieving optimal AP pelvic images. The most common technique calls for the technologist to palpate the ASIS and center the central ray and image receptor on an imaginary line that lies midway between the ASIS and symphysis pubis. This method relies heavily on
In the Clinic

The Bent Knee Method for Imaging the Pelvis

The hip is surrounded by thick muscles. The muscles that flex the hip, including the iliopsoas, the iliacus, and psoas major muscles, are in front of the hip joint. This deep muscle group begins in the low back and pelvis and connects on the inside edge of the upper femur. The sartorius, the longest muscle of the body, originates at the ASIS and extends to the medial side of the tibial tuberosity (see Figure 2). Its function is to flex the thigh and leg and to rotate the lower leg medially and the thigh laterally. When the patient’s leg is flexed, the sartorius is felt as a thick band medially and distally to the ASIS. Several muscles—the iliopsoas, sartorius, tensor fasciae latae, rectus femoris, adductor longus, adductor brevis, and pectineus—are collectively termed hip flexors because their primary function is flexion of the hip. The crease between the hip and the thigh, where the femur rotates in the acetabulum, is the hip flexion crease.

Radiologic technologists are experts at skeletal landmarks but are not taught many muscular landmarks, although muscular landmarks often are found easily. With the typical method of positioning, when the line that is imagined between the ASIS and the symphysis pubis is bisected, the bisection falls at the top of the acetabulum. Just lateral to that point is the muscular part of the hip between the ASIS and the greater trochanter. According to Casey I Huntsman, MD (personal communication, May 13, 2010), when a person’s leg is flexed, that muscular area is directly under the flexion crease, and the sartorius is palpable.

To use the bent knee method to ensure the radiograph will include the entire pelvis and both lesser and greater trochanters of the femurs (see Figure 3), the technologist should follow these steps:

- Have the patient lie supine on the table.
- Center the x-ray tube over the Bucky and image receptor.
- Have the patient bend the unaffected leg and rest the foot on the table.
- Move the table so the central ray rests at the hip flexion crease at the most anterior point.
- Place his or her hand on the crease and feel the sartorius muscle flex to ensure correct position (see Figure 4).
- Have the patient lay the leg back down and center the patient side to side, checking for pelvic rotation (see Figure 5).
- Have the patient turn his or her feet 15° to 20° as for any AP pelvis technique.
- Ensure the 40-inch source-to-image distance and optimal exposure techniques.

This technique allows the technologist to ensure well-positioned AP pelvis radiographs almost every time, on
all body types, and without palpation or imagining where anatomy lies. If the patient has had a total hip prosthesis implanted, center a hand’s width lower and compromise the top of the iliac crest to image the entire prosthetic.

Lacey Moon, R.T.(R)(M), is the head of the radiology department for Biddulph and Huntsman Orthopedic Surgery in Idaho Falls, Idaho. She has worked in the radiology field for more than 11 years, and in that time, she has found that many alternate positioning techniques can be used to obtain high-quality radiographs without putting the patient in awkward or painful situations.

References
Teaching Techniques

Flipping the Classroom With Screencasts

Daniel Neil DeMaio, MEd, R.T.(R)(CT)
Claudia Edwards Oakes, PhD, OTR/L

Students in medical imaging programs must develop effective problem-solving skills to become successful technologists. Therefore, instructors must deliver highly technical information clearly and ensure that students can apply the facts to solve practical problems in clinical situations. Traditionally, instructors begin by lecturing about a topic that requires students to solve problems. Then, after providing an example, the instructor assigns additional problems for students to solve at home. Students usually are left on their own to figure out the solutions, and if their efforts are not effective, they might not have adequate resources to solve the problems by themselves. Students also might struggle with transferring factual knowledge to real-life problems. Students and instructors might want to spend more time in class working on strategies to solve difficult problems, but time constraints limit the instructor’s ability to stay focused on one content area for a prolonged period. A “flipped” classroom could offer a solution for instructors who want to maximize the use of class time.

The flipped classroom is an inverted approach in which the students’ homework is to view a recording of the lecture, and class time is used for active problem-solving activities with instructor guidance. Flipping the classroom allows instructors to gauge students’ understanding of the concepts and provide further instruction if they identify deficiencies in the students’ knowledge base. Instructors also can assess the types of mistakes students make to help prevent them from developing poor habits. Working together in the classroom allows students to practice solving increasingly difficult problems that vary in context. The flipped classroom is garnering significant attention for its potential to deliver a variety of benefits.1-4

Flipping the Medical Imaging Classroom

The flipped classroom technique can be applied to numerous medical imaging topics requiring student problem-solving skills. The technique begins with an introductory screencast that students are assigned to watch prior to a class meeting. The term screencast refers to the video capture of an entire computer screen while software is in use, usually with accompanying audio narration.5 The screencast might be a recorded video or a slideshow presentation that introduces a topic and provides examples of the types of problems students might encounter. Instructors should limit the length of the screencast to 15 or 20 minutes to keep the content manageable and maintain students’ attention. Students can access the screencast via e-mail, the school’s course management system (eg, Blackboard, ANGEL, or Moodle), or a Web site, blog, or wiki Web application. Posting the screencast to a course management system allows the instructor to track which students watched the recorded lesson.

Students must understand the importance of viewing the screencast prior to the scheduled class meeting to ensure that they are prepared to solve additional problems under the instructor’s supervision. During class time, students work individually or collaboratively...
on sample problems of varying contexts and degrees of complexity. The instructor informally assesses student comprehension and provides direct assistance while moving around the classroom.

The University of Hartford in Connecticut has used the flipped classroom technique in radiographic principles courses for many problem-based topics including inverse square law, density maintenance, radiation unit conversions, and the geometry of imaging. One screencast, for example, provides a review of the calculation of the radiographic magnification factor for a given imaging system. The screencast includes examples of the straightforward use of the 2 formulas typically applied to magnification factor problems:

\[ \text{Magnification factor (MF)} = \frac{\text{Source-to-image receptor distance (SID)}}{\text{Source-to-object distance (SOD)}} \]

\[ \text{Magnification factor (MF)} = \frac{\text{Image size}}{\text{Object size}} \]

Students view the screencast, and then during the next class meeting, they work in small groups to solve the problems with the instructor providing direct assistance as necessary. The problems present clinical scenarios in which students are required to solve for a single or multiple unknown factors.

**Sample Problem**

After viewing the screencast, students should be able to solve problems like this one:

A 12.4-cm heart projects to a size of 13.5 cm on a radiograph. If the image were produced at a source-to-image receptor distance of 180 cm, how far from the image receptor was the heart positioned during the acquired projection?

Initially, students might fail to recognize that both formulas must be used to solve this problem. Having students solve the problem in groups allows the instructor to determine whether all students understand that the first step toward finding a solution is calculating the magnification factor. Once calculated, the magnification factor is used to solve for the source-to-object distance, which can be subtracted from the source-to-image receptor distance to yield the correct answer.

Encouraging students to work together incorporates peer instruction. Working in small groups allows students to share problem-solving strategies and identify best practices, eliciting the guidance of the instructor as needed. Research has suggested that peer instruction improves learning outcomes.

**Technical Requirements**

Presentations for the flipped classroom can be developed and recorded in several ways such as podcasting, vodcasting (video podcasting), video-based lecture capture, and Web conferencing. The University of Hartford’s sample screencast was produced using Apple hardware and compatible software including PowerPoint (Microsoft) and the screen capture function of QuickTime Player 10.0 (Apple Inc). The QuickTime software allows the user to easily capture all of the actions displayed on the computer screen and is free to both Mac and PC users.

Voice narration was recorded simultaneously through a podcasting microphone (Samson Go Mic; Samson Technologies) to improve audio quality. However, the recording capability of a typical laptop or personal computer would be sufficient. Freehand text and drawings were added with a digital tablet and pen.
(Intuos; Wacom), which connect easily to a computer through a standard USB port (see Figure). Once the microphone and digital tablet are connected, the user runs the PowerPoint slideshow in presentation mode while QuickTime is activated. The sample screencast (a “.mov” file) was recorded on an Apple device, but all of the hardware is compatible with Microsoft PC products. In addition, several excellent screencasting softwares are available for both PC and Mac, including Camtasia Studio, Jing, Snagit (TechSmith), and Adobe Captivate. See the Box for more information about the technologies described in this article.

Conclusion

The flipped classroom technique was incorporated into the radiography curriculum at the University of Hartford in 2011. Feedback generally has been positive, with students supporting the use of screencasts in their comments on course evaluations. Additional research is needed to assess the direct effect of the flipped classroom on student learning outcomes.

Potential pitfalls of the flipped classroom technique can limit its effect, however. It is critical for students to watch the screencast before attending a class session devoted to problem solving. To avoid frustrating students who prepared for class, the instructor should not begin the class by explaining the material for students who did not watch the screencast.

Even if all students watch the screencast before class, some will grasp the content better than others. Requiring the students to work collaboratively is one solution to address this fact. Stronger students can assist those who need additional help, which could be beneficial for all involved.

Some students might want the opportunity to ask questions during the screencast lecture. Encourage students to write down their questions and discuss them during the next class meeting. The combination of self-directed and instructor-guided learning experiences might benefit student outcomes.

The flipped classroom technique is an easy and convenient way to offer students additional learning support. From an instructor’s perspective, flipping allows for more productive in-class time because the instructor can coach students as they work, improving understanding and performance.

Daniel Neil DeMaio, MEd, R.T.(R)(CT), is an assistant professor and director of the radiologic technology program at the University of Hartford in Connecticut. He can be reached at ddemaio@hartford.edu.

Claudia Edwards Oakes, PhD, OTR/L, is an assistant professor and director of the health science program at the University of Hartford.

References


An Overview of Radiologic Technology Programs in Brazil

Fabiano de Castro Justo, MS

Brazil occupies an area of 8,515,767 sq km and has a population of 190,732,694. According to the country’s Guidelines and Bases of Education Law of 1996, the Brazilian education system has 3 levels: basic education, undergraduate, and graduate. The guidelines divide undergraduate education into 3 distinct programs: bachelor’s degree, bachelor’s degree for teacher training, and associate degree, which in Brazil is called a technological undergraduate degree. Both the bachelor’s degree programs and the associate degree programs allow students to access master’s or doctoral programs.

All bachelor’s degree programs increased 250% in Brazil between 1998 and 2008. Associate degree programs increased 1200% during the same period, which shows a preference for short-term programs focused on gaining employment. Currently, there are 131 radiologic technology programs in Brazil, with 28 in the state of São Paulo, which has a population of 41,262,199.

The first Brazilian radiologic technology associate degree was offered in 1992 by the Universidade Luterana do Brasil, or the Lutheran University of Brazil, in the southern city of Canoas. The program was based on others around the world but adapted to Brazilian needs. The first students completed the program in 1995. The current radiologic technology curriculum at the Lutheran University of Brazil is shown in the Table.

Associate degrees in Brazil are structured according to skills and abilities determined by the needs of the labor market. The degree programs should be guided by 3 principles: flexibility, the use of interdisciplinary information, and the use of contextual information. The programs can be modular, focused on certain subjects, and require completed projects or other educational activities.

History of the Associate Degree in Brazil

Brazil’s increasing investment in infrastructure and expansion of industry, especially the automotive industry in the mid-1950s and early 1960s, made it necessary for professional qualifications to meet market demands. As a result, the Guidelines and Bases of Education Law of 1961 established new educational guidelines and reformulated industrial education. By the end of the 1960s, short-term undergraduate courses were created, but they suffered from a lack of credibility, which put the guidelines into disrepute. However, the 1996 guidelines changed the educational system to offer universities more autonomy to create new programs.

A resolution by Brazil’s National Council of Education defined the professional areas of concentration, such as courses in health or administration, and the course load requirements of each program, which clarified uncertainties about associate degrees. In December 2002, these definitions were consolidated by the same council that defined the Associate Degree National Curriculum Guidelines, which addresses the characteristics that should be observed in those who obtain an associate degree. Arguably, the role of these guidelines was important, as they provided technical and scientific support.

Radiologic Technology Programs

According to the Brazilian Ministry of Education, associate degrees are undergraduate degrees with specific characteristics. Therefore, pedagogical projects should...
focus on skills and abilities as well as development of research and technological innovation.

Radiologic technology associate degrees follow the Brazilian minimum recommendations of the 2010 Associate Degree National Guide provided by the Brazilian Ministry of Education, which defines the professional profile, infrastructure, and minimum workloads for many professions. The guide defines a radiologic technologist as a professional who performs:

- Radiologic techniques for diagnostic procedures.
- Radiotherapy for therapeutic procedures.
- Radioisotope manipulation for radioisotopic procedures.
- Industrial radiography procedures.
- Nuclear medicine procedures.

Furthermore, this professional can coordinate radiological procedures with biosafety standards and radiation protection for hospitals, polyclinics, laboratories, industries, and manufacturers and distributors of hospital equipment. The radiologic technology programs must have a minimum infrastructure that includes:

- An anatomy lab.
- A dosimetry and radiation protection lab.
- A computer lab with specific programs.
- A processing and image analysis lab.
- A radiology lab.
- A nursing lab.

The Brazilian Ministry of Education does not require the program to be located at a teaching hospital, but a student’s workload must include at least 2400 hours in class over 6 semesters. Clinical experience and a term paper are elective content, according to the ministry. However, the National Radiologic Technology Council requires that a minimum of 20% of a radiologic technology student’s total workload be clinical experience.

The Associate Degree National Guide could be an important benchmark of curricular design for radiologic technology schools, but it does not mandate a specific educational pathway. Instead, it outlines general guidelines and minimum requirements that programs must meet to ensure that graduates are prepared for the demands of the profession.

### Table: Current Radiologic Technology Curriculum at Lutheran University of Brazil

<table>
<thead>
<tr>
<th>Radiologic Technology Curriculum</th>
<th>Hours</th>
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<td>Anatomy</td>
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<td>Radiation physics</td>
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<td>Portuguese language</td>
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<td>Quality control in radiology</td>
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Global Outlook

An Overview of Radiologic Technology Programs in Brazil

not set specific guidelines. Brazil’s National Student Performance Exam has served as a reference for radiologic technology associate degrees, as well as for other programs.11,12 The National Student Performance Exam is a test that evaluates almost all higher education programs in Brazil every 3 years. Several degree programs, including radiologic technology, were evaluated in 2007 and 2010. The contents of the exam are determined by the Ministry of Education Evaluation Committees, whose members are chosen by Brazil’s National Institute for Educational Studies and Research, according to its standards for academic excellence in radiology.11

From 2007 to 2010 there was an increase in the content covered by the National Student Performance Exam. The questions became more contextual and more in line with existing technologies, techniques, and procedures. As a result, the test now is used to define specific guidelines for radiologic technology programs in Brazil.

**Conclusion**

Although the number of radiologic technology programs offered in Brazil has increased over the years, it is necessary to reach a consensus on the content addressed by individual programs. The National Student Performance Exam could support national educational policies and help define national guidelines for radiologic technology education programs. The 3-year cycle of curriculum evaluation must show that these programs focus on the technological and scientific aspects of radiologic technology, along with ethics, a multidisciplinary approach to learning, and behavior that reflects the value of patients. The Ministry of Education, supported by professionals in the field, should define the requirements that are important and that will support the profession. Though a laborious process, it is important for the future of radiologic technologists so that we will be equipped to attend to the needs of more people with a high quality of care.

**References**


Fabiano de Castro Justo, MS, has a master’s degree in dental radiology. He is an education specialist and director of the radiologic technology graduate program at the Lutheran University of Brazil. He currently works in the radiology department at Fêmina Hospital in Porto Alegre, Rio Grande do Sul. He can be reached at justo.fabiano@gmail.com.
Quality Control

Quantum Mottle Query

I read with interest your recent article titled “Quantum Mottle and Exposure Indices” by Thomas Sandridge (Technical Query, July/August 2013 Computed Tomography edition). The article clearly explains the link between quantum mottle, signal-to-noise ratio (SNR), and exposure index (EI) while relating this to diagnostic image quality.

However, there are a wide variety of other factors that can affect the EI of an image to a greater or lesser extent, including exposure factors other than mAs, collimation field applied, correct radiographic technique, and appropriate image processing and look-up tables applied at image acquisition. Similarly, correct radiographic technique and collimation can significantly improve the resultant image quality with little or no effect on the EI of the acquired image.

The article also raises an important issue regarding the acceptable quality of an image and who should be the final arbiter of this. This may vary between locations and countries, but shouldn’t the final decision on image acceptability rest with the radiology department staff or physicians, including radiologic technologists, advanced practitioners, or radiologists, rather than those in an external unit such as the emergency department? The emergency physician in your case may have decided that he was only concerned with whether there had been successful reduction, but as a reporter of the images, I would also require sufficient image quality to enable confident exclusion of other pathologies after the successful reduction.

K Flintham, BSc, PGDip
Advanced Radiographer Practitioner
Wakefield Pinderfields Hospital
The Mid Yorkshire Hospitals NHS Trust
Wakefield, England

The Author Responds:

Although image noise can indeed be caused by other factors, the exposure factors used to obtain the particular image were known at the time the article was written. Additionally, I spoke with the technologist to ascertain if other factors could possibly have caused the mottle. The exposure factors used, in particular the mAs, were lower than usual, resulting in quantum mottle and poor SNR. Additionally, the EI for the image was well below the established range of acceptable exposures for that imaging facility. As in all imaging facilities, the “acceptable” range for SNR and target EI numbers is defined by the radiologists.

I completely agree with your point that staff in the department should not be the ultimate individuals deciding on image quality. Technologists are trained to produce images meeting the expectations of the interpreting radiologists. The radiographer, in
most facilities, is usually the individual determining the initial acceptability of images. In larger facilities, the technologists usually approve their images and then submit them to PACS for the radiologist to interpret. Radiology departments have a mechanism in place whereby image quality is continually monitored and, when necessary, corrective action taken. Radiologists, the ultimate determining parties, will notify the necessary technologist or quality control individual of unacceptable images. This feedback is used as part of routine QC procedures. When imaging protocols are developed by facilities, important factors guiding the process are radiologist preference and the exposure tolerance range. Technologists are informed of these ranges so they can produce images with acceptable SNR levels without overexposing the patient. In larger facilities, the radiologists are often working at remote locations and are not always available in real time. Part of being a technologist (rather than a technician) is knowing how to critique one’s own images and to formulate corrective action when necessary for improvement.

In the case used for the article, the emergency physician was unavailable for comment, but it is assumed he did not require a repeat exposure because of patient condition. The age of the patient and her presenting condition did not permit a repeat exposure, although the technologist was ready to attempt one. The image was not within the acceptable EI range, but there are occasions when patient condition may dictate whether an image can be repeated. Those situations are in no way ideal, but as you are aware, this is one of the many challenges facing technologists in clinical practice.

Thomas G Sandridge, MS, MEd, R.T.(R)
Program Director
School of Radiography
Northwestern Memorial Hospital
Chicago, Illinois
Hitting the Mark

When he noticed a radiographic marker was missing, radiologic technology student Delano James, a senior at Bronx Community College of the City University of New York, faced the inevitable task of tracking down “that last emergency department patient” or sifting through the 3 large bags of soiled linen adjacent to the emergency department examination room to find the marker. This was an unpleasant prospect in this busy New York City radiology department. To expedite the process, he inquired if he might be allowed to x-ray the bags as a means of simplifying the search.

Thanks to the speed and on-screen viewing of digital radiography, he located the missing marker without a noticeable delay for patients awaiting imaging examinations. The first shot on the second bag proved his idea was innovative, and he did not have to order another set of markers (see Figure). The staff radiologic technologists and I were impressed with his ingenuity. Who says today’s students lack sound critical-thinking skills?

Geraldine A Burghart, MA, R.T.(R)(M)(MR), is an associate professor and the clinical coordinator in radiologic technology for the Department of Nursing and Allied Health Sciences at Bronx Community College of the City University of New York. Burghart coauthored the Handbook of MRI Scanning. She has been a radiologic technologist for more than 30 years, with a primary focus on excellence in both didactic and clinical education for students as well as seasoned radiographers.
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But what of the future? The future is malleable, neither rigid nor predetermined. It is shaped by the will of men [and women] and the labors of those who work and think. There are influences over which we have no control, but our own influence is strong and continues to grow, and our future is more in our own hands than those of others. The record bears out the fact that we have acted wisely, judiciously and ethically. Should we continue, directed by such concepts as these, our contributions to our profession, to radiology and to medicine as a whole will continue to grow, and just reward in several forms will be ours.

This coronary angiogram shows a left main coronary artery blockage often referred to as the widow maker. A Judkins left catheter with a 4-cm reach (JL4) cannulates the os of the left main coronary artery at the aortic cusp. The left main coronary artery narrows just to the right of the aortic cusp and branches into the left anterior descending artery and the circumflex artery, which are both aneurysmal (dilated). The left ventricle is filled with residual contrast from coronary injection. The left main coronary artery branches into the left anterior descending artery, which supplies blood to much of the heart. In about 50% of people, the circumflex artery provides blood to the sinoatrial node, the heart's pacemaker. Here, more than 75% of the heart's blood supply is blocked. This type of occlusion is considered extremely urgent. If too much time passes before intervention, heart muscle deteriorates and the tissue dies; thus, it is difficult for the heart to return to normal function. Image courtesy of the Heart Hospital of New Mexico.

Portable x-ray machines can be mechanisms for transporting bacteria and viruses to the entire hospital campus.

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