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Errata

Page 178 of the “Medical Imaging and Infertility” Directed Reading, which appeared in the November/December 2016 issue, erroneously stated that Figure 8 was courtesy of Samia Long, AS, R.T.(R). The image actually is courtesy of Bontrager KL, Lampignano J, eds. Textbook of Radiographic Positioning and Related Anatomy. 8th ed. St Louis, MO; Mosby; 2014.

Thank you to the author who called this to our attention.
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**ON THE COVER**
The painting, “Knee Evolution,” by Kaitlin Walsh, portrays 3 artistic renditions of the knee joint. The juxtaposition of a newborn knee (top), a healthy adult knee (middle), and an aging knee joint with osteoarthritis (bottom) highlights the structural changes of our bodies as we age.
Student Perceptions of Online Radiologic Science Courses

Erika Papillion, MSRS, R.T.(R)
Laura Aaron, PhD, R.T.(R)(M)(QM), FASRT

Purpose To evaluate student perceptions of the effectiveness of online radiologic science courses by examining various learning activities and course characteristics experienced in the online learning environment.

Methods A researcher-designed electronic survey was used to obtain results from students enrolled in the clinical portion of a radiologic science program that offers online courses. The survey consisted of elements associated with demographics, experience, and perceptions related to online radiologic science courses. Surveys were sent to 35 program directors of Joint Review Committee on Education in Radiologic Technology–accredited associate and bachelor’s degree programs with requests to share the survey with students.

Results The 38 students who participated in the survey identified 4 course characteristics most important for effective online radiologic science courses: a well-organized course, timely instructor feedback, a variety of learning activities, and informative documents, such as course syllabus, calendar, and rubrics.

Discussion Learner satisfaction is a successful indicator of engagement in online courses. Descriptive statistical analysis indicated that elements related to the instructor’s role is one of the most important components of effectiveness in online radiologic science courses. This role includes providing an organized course with informative documents, a variety of learning activities, and timely feedback and communication.

Conclusion Although online courses should provide many meaningful learning activities that appeal to a wide range of learning styles, the nature of the course affects the types of learning activities used and therefore could decrease the ability to vary learning activities.

Keywords radiologic science courses, online learning, student satisfaction, learner comprehension, distance education, faculty interactions

Online courses are classes that do not require face-to-face meetings or on-campus activity; all learning elements are delivered online by facilitating student interactions with course content, the instructor, and classmates. Over the past several years, students have validated the significance of online learning in higher education. According to the 2014 Sloan Consortium report, online enrollments have increased at frequencies substantially greater than those of higher education overall, with nearly 7.1 million students taking at least 1 online course. Although online learning has increased in higher education overall, it has not been implemented extensively in the radiologic sciences, perhaps because of faculty-expressed barriers concerning online course delivery in radiologic science curriculums. Despite these concerns, a 2013 study by Kowalczyk and Copley revealed a 30% increase in the adoption of online courses in radiologic science programs between 2009 and 2012. These findings indicate a need to explore this growing instructional platform and to identify the course characteristics that help ensure student comprehension. Although faculty approval and support are critical to the success of any online educational curriculum, learner satisfaction and comprehension is a valuable commodity for developing online courses.
Studies show that student outcomes in online radiologic science courses are comparable to those of traditional courses. Researchers also have evaluated perceived barriers, overall acceptance, and methods for enhancing the development of online radiologic science courses. Although few studies have focused on overall student perception of online radiologic science learning environments, research in other curriculums has demonstrated that student perception and satisfaction are precursors to motivation, which strengthens engagement and increases comprehension in online learning environments. Evaluating student perceptions might enhance the online learning environment by providing faculty with valuable information when designing online radiologic science courses.

**Literature Review**

Studies, although scant, have demonstrated outcome comparisons of online vs traditional radiologic science courses consistent with findings in other disciplines. A study by Britt that evaluated student perceptions of grade differences between online and traditional courses indicated nearly even attitudes. Nearly half of students indicated a difference in grades between the 2 course formats, whereas a little more than half reported no difference. Comparably, in 2008 Johnston found that, overall, online learners received higher course grades than did students in the same traditional course. Johnston suggested that this finding supported the concept that online students interact more with course content, which resulted in deeper comprehension. A similar study by Cook evaluated exam scores of students in a traditional radiologic science positioning course with its online equivalent and found no significant differences in the 2 formats. Each of these studies validates that radiologic science students can obtain satisfactory results in online courses. Nevertheless, many researchers suggest that many factors—not just outcomes—must be examined to determine comprehension in the online environment.

Researchers have suggested that specific factors, such as benefits, barriers, and online learner requirements, should be evaluated when developing online courses. Many in the radiologic science profession have acknowledged numerous benefits of online education. Radiologic science educators and students concur that online course offerings benefit education programs as well as students. These benefits include increased student enrollment because of accessibility, less travel, program expansion beyond immediate geographical regions, and the convenience of learning at any time. In addition, studies have shown that online learning components enhance and encourage self-directed, lifelong learning.

Despite these benefits, apprehension still exists. For every piece of research that demonstrates comparable outcomes, other research exists that demonstrates barriers to the integration of online radiologic science courses among students and faculty. Faculty in Britt’s study, for example, identified lack of preparation time, limited student-instructor contact, and unfamiliar technology as disadvantages to online courses. Similarly, respondents in Rosenkoetter’s study identified assessment methods, conversion of content, lack of communication, and cheating as barriers to implementing online radiologic science courses. Interestingly, previous studies confirmed that students and faculty agree that some radiologic science courses are unsuitable for online delivery. A 2008 study of online radiologic science educators revealed 3 distinct barriers: information technology training and support followed by student-related and institutional barriers. Many respondents in this study did not feel adequately trained in using online technology and felt they lacked the necessary technological and institutional/peer support for delivering online courses. Respondents also indicated online security as well as student engagement and interest as barriers to online radiologic science courses. To provide quality online educational experiences for radiologic science students, it is important to identify methods of overcoming these perceived barriers.

Unlike in face-to-face courses, instructors in online learning environments are unable to visibly assess student comprehension or satisfaction. Student perceptions have been observed as critical in determining the characteristics that support comprehension in online courses. Many elements in course design have been shown to contribute to student perceptions of efficacy in online education. Researchers affirm that online courses should allow students to make independent
choices during the learning process, supported by effective learning elements. Similarly, studies indicate that encouraging independent learning through instructor interaction and feedback is important to the online learner. Equally, after studying student evaluations of online courses, Jones found that students want an organized and structured course, clear expectations, relevant and useful learning materials, frequent interaction, and timely feedback from the instructor. Moreover, studies have indicated that online learners value not only interaction with the instructor, but peer interaction as well. In addition, online students perceived sound course design, clear course instructions and expectations, adequate learning materials, and instructor-provided resources as effective learning elements.

With the growth of online education, specifically in the radiologic sciences, it is imperative that educators persistently strive to provide sound learning opportunities for students enrolled in online courses. Identifying student perceptions has proven to provide essential information for increasing engagement and comprehension in online courses. Educator commitment to modifying and adapting teaching methods based on student requirements is essential for the advancement of online learning in radiologic science curriculums. Researchers recommend studying perceptions of the needs and characteristics of online radiologic science students to achieve better course design.

Methods

An electronic survey, designed by the researchers, was conducted to evaluate student perceptions of effective learning elements in online radiologic sciences courses. The survey consisted of items related to demographic information and student experiences and perceptions related to online radiologic sciences courses. After receiving approval from the Northwestern State University institutional review board, program directors of the Joint Review Committee on Education in Radiologic Technology–accredited associate and bachelor degree programs that were identified as having a distance education component were asked to share the survey with their students. Thirty-five program directors were sent the request; 2 emails came back as undeliverable. The survey link and an explanation of the study were sent to students enrolled in the clinical portion of those programs that participated. A reminder email was sent to the program directors 1 month later to request additional participation. Results were analyzed using descriptive statistics.

Results

Thirty-eight students responded to the survey. Of these, 82% were women and 53% were aged between 19 and 23 years. The respondents were divided equally between associate and bachelor’s degree programs and 58% self-identified as seniors in their programs. Forty-three percent of the respondents had taken 1 to 2 online radiologic science courses; 8% had taken more than 6. The most common learning style selected by the participants was kinesthetic (46%). Table 1 shows the demographic characteristics of the participants.

Figure 1 illustrates the types of online courses the respondents had taken. Medical terminology was the most commonly taken online course, with 74% of students indicating having participated. Sectional anatomy (38%), introduction to radiology (35%), and ethics (32%) were other commonly taken online courses. Figure 2 demonstrates the types of learning activities employed in online courses taken by the respondents. Quizzes and exams (94%), discussion boards (81%), and textbook readings (75%) were the most common activities. To determine whether various learning activities in the online radiologic science courses support comprehension and retention of course content, participants were asked to rank the following items:

- Feedback from quizzes, exams, and assignments.
- Interaction with classmates in group projects or discussion boards.
- Supplemental learning materials, such as online resources, videos, articles, additional reading materials, or a combination of these materials.
- Research and writing assignments.

Respondents ranked these learning activities from 1 (least supportive) to 4 (most supportive). A mean was calculated to determine which activities were perceived as supportive and unsupportive. Results indicated that respondents identified feedback from quizzes and exams...
to 5 = strongly agree) corresponding to various course characteristics to determine which are important to students in online radiologic science courses. Table 2 displays the mean rating of each characteristic. Results demonstrate that respondents perceive that the following course characteristics are most important for effective online radiologic science courses:

- A well-organized course.
- Timely instructor feedback.
- Documents, such as course syllabus, calendar, and rubrics.
- A variety of learning activities.

When asked whether respondents would recommend an online radiologic science course to a friend, 58% would, based on their experience with an online radiologic science course. Some of the comments from students supporting online learning include: “While I have not taken many radiology classes online, I have
A variety of learning activities, and informative documents, such as a syllabus, calendar, and rubric. These results are congruent with previous findings on the instructor’s role in course organization and design.  

Although participants linked various learning activities with greater comprehension in online radiologic science courses, study results showed a disproportionate variety in the types of online learning activities, with the majority being quizzes and exams, discussion boards, and textbook readings. More than 90% of respondents indicated that quizzes and exams were used as a learning activity in online radiologic science courses. This finding possibly supports results indicating that feedback from quizzes and exams contributed more to comprehension than any other learning activity. A previous study of radiologic science educators indicated that discussion boards were one of the most often used learning activities. 5 Likewise, discussion boards were indicated as one of the most commonly employed learning activities in this study. However, the majority of participants perceived discussion boards as a least supportive method to comprehension. In fact, participants in this study indicated that learning activities involving peer interaction contributed least to comprehension in the online learning environment than any other learning activity. These results contradict those of previous researchers regarding peer interaction in online learning environments. 12,13,18 These findings suggest that online courses should provide more meaningful learning activities that connect course content with peer and instructor communication, as demonstrated in previous research. 12,13,17,18

Most students indicated having a kinesthetic, or hands-on, learning style. However, the most frequent learning activities encountered by participants in this study involved reading and writing, not hands-on activities. Although the radiologic science curriculum includes many traditional courses where hands-on strategies comprise a large portion of learning activities, incorporating these strategies into online courses can be difficult. Nevertheless, researchers suggest incorporating a multitude of learning activities in the online learning environment to appeal to a wide range of learning styles. 13 However, considering that medical terminology was the course most commonly taken

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<td>A well-organized course is important for effective learning in online radiologic science courses.</td>
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<tr>
<td>Timely instructor feedback is necessary and supplements my understanding of course content.</td>
<td>4.6</td>
</tr>
<tr>
<td>Supplemental resources, when provided by the instructor, aid in my comprehension of online course content.</td>
<td>4.03</td>
</tr>
<tr>
<td>Interacting with classmates, through online learning activities and/or group projects, plays an important role in my comprehension in online courses.</td>
<td>3.34</td>
</tr>
<tr>
<td>Participation in online courses encourages me to be an independent learner.</td>
<td>3.97</td>
</tr>
<tr>
<td>Instructor-provided documents such as course syllabus, calendar, and rubrics supplement my ability to learn in online courses.</td>
<td>4.34</td>
</tr>
<tr>
<td>A variety of learning activities is necessary for comprehension in online radiologic science courses.</td>
<td>4.23</td>
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should design a well-organized course with adequate and relevant course materials, foster meaningful engagement between students and content, and provide frequent and timely feedback. Furthermore, students indicated that a variety of learning activities contribute to comprehension in an online course but that many online courses lack the optimal variety needed. These results likely are connected to the faculty-related barriers mentioned. Faculty might be able to overcome these barriers by implementing the Quality Matters Rubric, which is a compilation of standards used to evaluate online course design.19

Future research should evaluate whether online radiologic science instructors assume the role that this study’s participants perceived as valuable for comprehension in the online learning environment. Likewise, it might be beneficial to determine, on a larger scale, whether a variety of learning activities are being used in online radiologic science courses. In addition, a study determining the types of online learning activities suitable for and applicable to course content and student learning styles might be useful.

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References


University Student Awareness of Skin Cancer: Behaviors, Recognition, and Prevention

Megan Trad, PhD, MSRS, R.T.(T)
Lawrence Estaville, PhD

Purpose Skin cancer is the most common cancer, and it often is preventable. The authors sought to evaluate behavior and knowledge regarding skin cancer among students at a Texas university.

Methods The authors recruited a diverse group of students in terms of sex, age, and ethnicity to participate in a survey regarding knowledge of skin cancer signs, use of tanning beds, and performance of self-assessment for skin cancer. Participating students could complete surveys in classrooms, at health fairs, or online via Survey Monkey. The authors examined data for the 3 variables in relation to sex, ethnicity, and age.

Results A total of 512 responses were completed. Female students completed 371 (72.46%) surveys, and male students completed 141 (27.54%). The ethnicity of student participants was nearly evenly split among whites, African Americans, and Hispanics. Ethnicity was the most significant factor influencing the knowledge of skin cancer and behaviors to prevent it. Specifically, Hispanic and African American students possessed a lower level of skin cancer awareness.

Discussion More female students than male students used tanning beds, and although use was self-reported as infrequent, the results imply that 4500 of the university’s students might use tanning beds, which is concerning if extrapolated to other university student populations in Texas.

Conclusion Behavioral intervention is critical in reducing students’ risk of skin cancer in later years, and university students must acquire knowledge to increase their awareness of skin health and to minimize their risk of developing skin cancer. Radiation therapists are uniquely positioned to share knowledge of skin cancer.

Keywords | skin cancer, university students, cancer awareness, cancer prevention

Skin cancer is the most common form of cancer diagnosed in the United States; approximately 3.5 million basal and squamous cell carcinomas and 73 000 melanomas were diagnosed in 2015. Skin cancer prevention and screening education and research are abundant, and numerous cancer prevention campaigns have attempted to alter individuals’ behaviors concerning sun and tanning bed exposure. Research has shown that primary prevention is the most effective route to reducing the incidence of and mortality from skin cancer and that skin care education at an early age is the best protection. However, despite the abundance of evidence available, young adults have resisted changing their harmful behaviors.

Literature Review

Unprotected exposure to sunlight, especially during peak sun hours, and the use of tanning beds are the top behaviors associated with an increased risk of skin cancer. The U.S. Department of Health and Human Services has categorized tanning beds as carcinogenic, yet use of these facilities remains high. In addition, the Centers for Disease Control and Prevention (CDC) has indicated that indoor tanning is especially dangerous during adolescence and early adulthood. Despite these warnings, the use of indoor tanning beds, specifically among college-aged individuals, is high. Playforth et al reported in 2014 that 68% of students in the authors’ sample had used a tanning bed at...
some point, and 80% indicated that having a tan was very important or somewhat important. Of those who ranked having a tan as important, most were women. In the same year, Jeong-Ju and Won-Moo reported that some college-aged women felt emotional benefits from using tanning beds that perpetuated their use even when the women understood the health dangers. In fact, the study found that college-aged women valued the positive emotional benefits of tanning more than the health benefits achieved through avoiding tanning.

The literature indicates that educational programs outlining the risks of sun exposure and use of tanning beds can lower student risk of developing skin cancer if students comply with the prevention methods provided. However, a 2008 CDC study about the use of sun protection methods—specifically wearing sun protection factor (SPF) 15 or higher, wearing sun-protective clothing, and seeking shade—reported that only 60% of individuals 18 to 24 years used 1 or more of these methods on a regular basis. The low use of preventive methods underscores the need for more education for these young adults. Furthermore, it is important to begin identifying ways to encourage young adults to follow the suggested guidelines.

Rules and regulations can help guide individuals toward healthier lifestyle choices. For example, in 2013 the Texas legislature banned minors from using commercial tanning facilities, thereby attempting to reduce the number of future skin cancer cases. No such restrictions exist for college-aged adults at a time in their lives when they are more likely to engage in risky behavior, including placing themselves in greater jeopardy of developing cancer.

This study is an effort to better understand university student knowledge and perceptions about skin cancer—its prevention, behavior that could lead to skin cancer, and warning signs. Much of the research focuses on how sex differences affect levels of knowledge and lifestyle choices related to skin health. Very little research investigates whether ethnicity or age are factors in skin cancer knowledge or in participation in healthy skin habits such as performing self-checks, annually visiting a dermatologist, and avoiding tanning beds.

As a result of the literature review, this investigation reports on 3 variables that could contribute to the possibility of university students’ developing skin cancer at some time during their lives: use of tanning beds, awareness of skin cancer warning signs, and the frequency of skin cancer self-checks. The researchers chose 3 questions that address college students’ current behavior, recognition of skin cancer, and use of preventive measures to lower the risk of developing skin cancer. The study also examines trends related to sex, ethnicity, and age, thereby adding to the current literature.

**Methods**

The objectives of the study were 3-fold: to understand university student knowledge of skin cancer prevention and risks, to determine whether students know what skin cancer looks like, and to ascertain whether students are conducting skin self-checks. Three specific research questions guided this research:

1. Do differences exist in the use of tanning beds according to sex, age, or ethnicity (non–Hispanic white, Hispanic, and African American)?
2. Do differences exist in the ability to identify skin cancer according to sex, age, or ethnicity?
3. Do differences exist in the commitment to conducting skin cancer self-checks according to sex, age, or ethnicity?

A survey asked students at a large Texas public university (> 37,000 students) about their perceptions and knowledge of skin cancer, whether they use tanning salons, and whether they conduct self-examinations for skin cancer. The study was approved by the university’s institutional review board. During the 2014 to 2015 academic year, students completed the survey 1 of 3 ways: in class, at health fairs, or online via Survey Monkey. This 3-pronged convenience sampling strategy enabled the recruitment of a diverse group of students, particularly regarding sex, age, and ethnicity. The total number of responses ranged from 515 to 521 undergraduate students (depending on skipped questions). Students self-identified their ethnicity as non–Hispanic white (hereafter termed white), Hispanic, African American, Asian American, or other. The number of Asian American students was so small (n = 21) that this group could not be included in the analysis because doing so would have skewed the results. Few students selected the “other” category
Results

A total of 521 university students completed the survey (6 students skipped survey questions resulting in different totals for some questions); of those, 371 (72.46%) were women and 141 (27.54%) were men. Regarding the question of ethnicity, 181 (35.35%) respondents self-identified as white, 182 (35.55%) as Hispanic, and 149 (29.10%) as African American. In identifying their academic classification, 123 (24.02%) self-identified as freshmen, 163 (31.84%) as sophomores, 139 (27.15%) as juniors, and 87 (16.99%) as seniors.

The student survey results showed that the use of tanning beds did not differ significantly between sexes, with 15% of women and 8% of men responding that they use tanning beds ($\chi^2 = 4.3, P = .365$). Use of tanning beds also did not differ significantly among academic classifications; responses were positive for 12% of freshmen, 13% of sophomores, 12% of juniors, and 14% of seniors ($\chi^2 = 4.4, P = .975$). However, the participants in the 3 ethnic groups differed statistically in their use of tanning beds ($\chi^2 = 24.4, P = .002$). White students’ use of tanning beds (25%) differed moderately from Hispanic student use (8%; $\chi^2 = 112, P = .018$) and strongly from African Americans (5%; $\chi^2 = 17.5, P = .002$). The use of tanning beds did not differ statistically between Hispanic and African American students ($\chi^2 = 2.6, P = .63$).

In the students’ self-reported ability to identify skin cancer (see Table), the evidence suggests a difference between the sexes; 38% of female students reported that they knew what skin cancer looks like and 29% of male students responded that they could identify skin cancer ($\chi^2 = 5.1, P = .077$). No difference in self-reporting of skin cancer identification occurred among the student classifications: freshman, 34%; sophomore, 32%; junior, 43%; and senior, 41% ($\chi^2 = 8.6, P = .196$). The 3 ethnic groups differed moderately ($\chi^2 = 9.7, P = .045$), with more white students than African American or Hispanic students stating that they could identify a skin cancer. Hispanic and African American self-reported ability knowledge did not differ significantly ($\chi^2 = 3.9, P = .142$).

Women (74%) and men (75%) in the survey did not differ in their reporting of never conducting self-checks for skin cancer, whereas 17% of women and 9%
of men reported that they perform self-checks each year ($\chi^2 = 4.4, P = .357$). Although the numeric trend suggests that older students conduct skin self-checks more often than do younger students, student classifications did not statistically differ in performing skin self-checks: those reporting that they never conduct checks included 78% of freshmen, 75% of sophomores, 74% of juniors, and 66% of seniors ($\chi^2 = 13.7, P = .319$). However, the 3 ethnic groups—white, Hispanic, and African American—differed statistically in conducting skin self-checks ($\chi^2 = 32.2, P = .000$). The number of white students who never perform self-checks (55%) differed strongly from Hispanics who never perform them (81%; $\chi^2 = 17.1, P = .002$) and African Americans who never perform them (86%; $\chi^2 = 25.1, P = .000$). Responses from Hispanics and African Americans to this question did not statistically differ ($\chi^2 = 1.0, P = .910$).

**Discussion**

The 3 specific research questions revealed:
- The use of tanning beds differs by ethnicity (white, Hispanic, and African American), but not by sex or age.
- The ability to identify skin cancer differs by sex and ethnicity, but not by age.
- Conducting skin cancer self-checks differs by ethnicity, but not by sex or age.

According to their self-reporting, approximately 12% of students use tanning beds, and most are women who claim annual usage, which initially seems encouraging. Yet, this percentage also implies that of more than 37,000 students in the university, about 4500 use tanning beds, an estimate that is concerning, especially if extrapolated to other university student populations in Texas. Although the variability by sex in this study was not as statistically significant as shown in earlier research, the trend is toward higher use of tanning beds among female students. This study might have revealed a growing trend of male students’ use of tanning beds worthy of further investigation.

The finding that 38% of women who reported knowing what cancer looks like was higher than the 28% of men who reported being able to identify skin cancer, yet three-quarters of both sexes surveyed claimed to have never conducted skin cancer self-checks. The data for the surrogate for age (student classification) showed little difference in tanning bed usage, at approximately 12% across the 4 groups. Further, data did not differ for knowing what skin cancer looks like; roughly 33% to 40% responded they could discern skin cancer.

Although the numeric trend showed that older students engage more often in skin cancer self-checks, no statistical difference was found among age groups based on student classifications.

As indicated previously, ethnicity is not reported often as a variable in the literature regarding skin health knowledge. Ethnicity, however, was pronounced in its variability regarding the 3 hypotheses. White students’ responses differed from those of Hispanics and African Americans for each of the 3 variables. Two-thirds of the 12% of students who used tanning beds (approximately 4500) students were white. Although this is not a surprising percentage, it has not been documented in previous research and is therefore a notable finding.

Responses to the question asking whether the students know what skin cancer looks like varied significantly, from 39% of white students to 25% of African American students. Forty-five percent of white students reported conducting self-checks for skin cancer, but fewer than 20% of Hispanics or African Americans indicated that they do. These findings are important, as it appears that white students, despite engaging in riskier behavior regarding skin health, also believe they have more knowledge of skin cancer appearance and say that they check for skin cancer more often. It is possible that the students who have darker skin color believe they are not as susceptible to skin cancer as are those who have lighter skin, a belief that is inaccurate. The false feeling of protection based on skin color might lead individuals to forgo skin checks, an omission that could lead to a later-stage diagnosis should skin cancer occur.

**Implications for Radiation Therapists**

This research is important to radiation therapists, who have been well educated on many aspects of cancer, including screening, prevention, detection, and treatment. Radiation therapists, who have treated many patients for skin cancer, are acutely aware that anyone is at risk of developing skin cancer, regardless of their sex, age, or ethnicity. Because of these experiences, radiation
therapists can use this knowledge to educate people, particularly college-age adults, to reduce their chances of developing cancer later in life. Ideally, doing so can create effective ways to share knowledge and diminish substantially the risk of cancer for future generations.

Conclusion

Much work remains in educating university students about skin cancer, its warning signs, and the dangers of using tanning beds. Specifically, this study reveals that tanning bed usage is not specific to age, gender, or ethnicity. Also, Hispanic and African American students need extra motivation to conduct monthly self-checks and to visit a dermatologist annually. More education is needed to determine how to better encourage young adults to adhere to guidelines and participate in preventive measures. College students are traversing a period in their lives in which behavioral intervention is critical if they are to reduce their risk of skin cancer in later years. It is imperative that these individuals acquire education to increase their awareness of skin health protection measures and of ways to minimize their risk of developing skin cancer.

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References


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Managing Multiple Generations in the Workplace

Kevin R Clark, EdD, R.T.(R)

Today’s workplace often includes workers from 4 distinct generations, and each generation brings a unique set of core values and characteristics to an organization. These generational differences can produce benefits, such as improved patient care, as well as challenges, such as conflict among employees. This article reviews current research on generational differences in educational settings and the workplace and discusses the implications of these findings for medical imaging and radiation therapy departments.

After completing this article, the reader should be able to:
- Identify the various generational cohorts in today’s workplace.
- Discuss distinguishing characteristics of each generation and describe their respective workplace behaviors.
- Describe the challenges and opportunities associated with a diverse workplace.
- Explain common stereotypes associated with each generation.
- Discuss the effects of generational differences on medical imaging and radiation therapy departments.

Today’s multigenerational workforce presents opportunities and challenges for medical imaging and radiation therapy departments. Because some employees are working into their late 60s and 70s, it is common to see several generational cohorts working together, creating a unique work environment. Although multigenerational diversity among health care staff can result in sound decisions and improved patient care, varied attitudes, values, beliefs, work ethics, and expectations can present challenges, too. As multiple generations continue working side by side, managers and organizations can promote a unified work environment by embracing generational differences and encouraging mutual understanding and respect.

Generations Defined
A generation is defined as a group of individuals born and living contemporaneously who share common knowledge and experiences that affect their thoughts, attitudes, values, beliefs, and behaviors. Although no consensus exists regarding when 1 generation ends and another begins, experts agree that individuals who grew up in the same era experienced social and historical events that shaped similar characteristics and core values.

Table 1 displays some of the historical and social events that influenced each generational cohort: veterans, baby boomers, generation X, and generation Y. It is important to note that individuals from a specific generation might not exhibit all or even any of the characteristics ascribed to the group as a whole. In fact, individuals might start to display characteristics of the next older generation as they advance in their careers.

Veterans
Veterans, also referred to as traditionalists and the silent generation, were born before 1946 and are the oldest generation in American culture.
55 million veterans reside in the United States today. Veterans are continuing to work later in life. In addition, health care organizations have a vested interest in understanding this generation because most Medicare beneficiaries—a significant portion of the health care consumer and patient populations—are veterans.

### Managing Multiple Generations in the Workplace

#### Baby Boomers

Baby boomers were born between 1946 and 1964 and are one of the largest generational cohorts in the United States, comprising about 76 million people. Those born between 1946 and 1955 are referred to as early boomers, and those born after 1955 are referred to as late boomers. Members of this generation grew up in a relatively steady state of free expression, economic prosperity, and an absence of world wars, although they lived through the Cold War era and the Vietnam War. As young adults, baby boomers experienced opportunities that were not available to their predecessors. Typically, they were the first in their families to earn college degrees, and their education translated into upward mobility. In school, baby boomers needed to collaborate and cooperate with their peers because there were so many of them. As a result, this generation possesses both teamwork and relationship-building skills.

Although some veterans train slowly, they make work a priority and are considered team players. They are loyal to their employers; expect the same in return; and believe promotions, raises, and recognition should be based on job tenure and seniority. They also measure work ethic on punctuality and productivity. As expected, veterans often are unsure of and even resist using new technology.

Most veterans have retired, and they constitute only 2% (3.7 million) of the U.S. workforce today. As a result, only limited research regarding their presence in the workforce is available. However, more and more people from this generation grew up during the Great Depression, and many fought or were children during World War II. The hardships of the war and the economy deeply affected this generation’s values and opinions regarding family, religion, work, and government. For example, veterans are characterized as being patriotic and civic-minded because they witnessed business and government working together during the New Deal to conquer the Great Depression. They also learned to be resourceful to stretch limited funds and make small amounts of food and clothing last. Having overcome economic hardships, they developed a sense of pride and determination and, as a result, tend to work hard and prefer consistency and uniformity. Described as loyal and disciplined, veterans also value integrity, character, and sacrifice; respect authority and value boundaries between work and family life; and strive for financial security.

### Table 1

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<td>Rise of labor unions</td>
<td>Television becomes dominant media</td>
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<td>September 11 events</td>
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#### Generation X

Generation X, also known as the “Little Leaguers,” were born between 1965 and 1980. They were born after World War II and the Cold War, and they grew up during the rise of labor unions and the civil rights movement. They were the first generation to experience the “baby boom” and were the first to feel the effects of the economy of the 1980s. They were the first generation to experience the effects of the economic recession of the 1980s and the start of the digital age. As a result, they are described as being pragmatic, realistic, and practical. They are often referred to as the “Generation X” generation because they were the first generation to be born after the baby boom, and they grew up during a time of economic stability and prosperity.

### Generation Y

Generation Y, also known as the “Millenials,” were born between 1981 and 1994. They were born after the end of the Cold War and the beginning of the digital age. They were the first generation to experience the effects of the economic recession of the 1980s and the start of the digital age. As a result, they are described as being pragmatic, realistic, and practical. They are often referred to as the “Generation Y” generation because they were the first generation to be born after the baby boom, and they grew up during a time of economic stability and prosperity.

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and proud of their strong work ethic. They also work longer work weeks than prior generations did, and they believe continual learning and growth lead to success. Motivated by perks, prestige, and position, baby boomers want to be recognized for their contributions, and they view work as an exciting adventure.

Baby boomers represent approximately 29% (44.6 million) of today’s U.S. workforce. The oldest members of this generation are considering their retirement options and are seeking ways and opportunities to make their elder years personally meaningful.

**Generation X**

Members of generation X, also referred to as gen Xers, busters, and the lost generation, were born between 1965 and 1980. Approximately 53 million members of the generation X cohort live in the United States. The term buster describes this generation because their birth rates were vastly lower than those of the baby boomers. The lost generation also describes this cohort because it was the first generation of latchkey children—those left at home with negligible parental supervision—and children exposed to daycare and divorce. Many parents of generation X were baby boomers with workaholic tendencies driven by personal gratification, authority, and status. In some cases, their work habits resulted in poor home lives, broken families, and absent parents. A lack of meaningful family relationships led generation X members to create nontraditional families by bonding with friends and colleagues.

Given their upbringing, it is no surprise that generation X members expect to maintain a balance between work and family life and do not work exceptionally long hours for money or titles. Generally, they are less loyal to their employers and are more comfortable demanding flexible work arrangements. They also expect freedom and balance in their personal and professional lives, acknowledging that work contributes only a portion of the quality of life they seek to achieve. At times, generation X can be cynical, questioning authority and disliking direct supervision. Often, they resist micromanaging bosses and find them to be distasteful and undesirable.

Considered independent, self-reliant, and informal, generation X individuals multitask easily and excel while working on independent projects. In fact, they do not align themselves with the philosophy of being a team member, but they will work with colleagues to achieve a common goal. They prefer to manage their own time, set their own limits, and complete their work without supervision. This generation also finds informal policies regarding dress codes and workplace habits to be fun and motivating. They expect and embrace change and are technologically savvy.

Generation X members represent approximately 34% (52.7 million) of the U.S. workforce today. Most thrive in a casual, friendly work environment; however, they desire to build portable careers by exploring employment opportunities and changing jobs periodically to increase their marketability.

**Generation Y**

Members of generation Y, commonly referred to as gen Yers, millennials, and nexters, were born between 1981 and 2000. This generation comprises about 80 million people and constitutes the largest generational cohort in the United States today. Having grown up using computers, mobile phones, tablets, and other electronic devices, generation Y individuals are extremely technologically savvy and highly connected to the Internet.

Unlike the latchkey children of generation X, generation Y grew up being escorted and supervised by protective parents who were extremely cautious of dangers such as kidnapping, school violence, and drugs. The close interaction between parents and child gave rise to the term helicopter parents, meaning parents who are involved in every aspect of their children’s lives. In general, generation Y members are less independent, more community-oriented, and seek a sense of meaning in greater contexts. This generation also is motivated by money and described as being ambitious, having a short attention span, and wanting instant gratification.

Compared with their predecessors, members of generation Y tend to be more social and confident as they seek a balance between their personal life and work. Although easily bored and impatient, they are motivated by their need for a sense of purpose and belonging to meaningful communities, and they typically enjoy experimenting and discovering new
approaches and solutions to problems. Often, this generation desires praise and support from employers to feel a sense of validation and belonging. In general, they expect more supervision and feedback, clear goals, and structure, and they learn best through mentoring programs.

In the U.S. workforce, generation Y just surpasses generation X at 34% (53.5 million). They are attracted to companies and businesses that embrace technological advancements that change the way of doing business globally. Being entrepreneurial, this generation engages in many jobs with diverse career paths. Because they seek happiness in their work and personal life, those of generation Y do not limit themselves to 1 job and 1 career.

Training and Education

As with the workforce, multigenerational differences often appear in educational and training settings. As higher education institutions continue to promote lifelong learning, classrooms are becoming more age-diverse. These classrooms expose future professionals to individuals from various generations and promote awareness of generational differences. As a result, education institutions and faculty must adapt to a changing classroom environment. To meet the needs of students and instructors, researchers are investigating various aspects of generational differences in the classroom, including learning preferences and technology use. This research can be used to design curricula, implement teaching strategies, and allocate resources.

Millennials’ Perspectives

Using a mixed-methods approach, Therrell and Dunneback conducted a study of 291 millennial college students regarding their perspectives on teaching and learning preferences. Their findings revealed that millennial college students preferred:

- A caring, passionate, and enthusiastic instructor.
- Clearly communicated course expectations.
- Course examinations that test only the content presented.
- Real work and practical applications of the content.
- Active learning strategies, such as role playing.
- Hands-on activities with interactive lab assignments and enjoyed real-world application scenarios over creative or reflective writing exercises.

In addition, the students appreciated personable professors who tailored their lessons to the group of individuals in a specific class.

Therrell and Dunneback acknowledged that their findings were consistent with the general characteristics of millennials, including short attention spans and the need for instant gratification. They also recognized the need for future studies involving larger samples to further investigate millennial students’ perspectives on teaching and learning in a variety of courses. Although this study assessed students’ preferences in the classroom setting only, it is possible that millennials bring those preferences into the workplace.

The Digital Divide

Salajan et al examined the perceptions of dental students and instructors regarding the use of digital learning technologies in the online classroom. Most of the instructors were either veterans or baby boomers, and most of the students were from generation Y. The researchers wanted to explore the assumption that younger generations are more technologically savvy and skilled than older generations. Specifically, the participants rated their use of email, web browsers, e-texts, personal computers, laptops, and MP3 players, as well as the course management system at the beginning of the semester and then at the end of the semester after using the digital technologies in the online classroom.

The results indicated a slight but not statistically significant intergenerational difference in faculty members’ perceived use of digital technologies, although the researchers did not investigate whether the difference was associated with generational differences between the veteran and baby boomer cohorts. However, students’ perceptions of the technologies improved over the academic year and were statistically significant. Students appeared to be more adept at using digital technologies than were their professors. However, the researchers warned that this conclusion was drawn from perceptual data at a rather general level of confidence (ie, not expert use). In addition, both students and faculty members were less satisfied with the course management system at the end of the
academic year than at the beginning.\textsuperscript{16} The researchers attributed the decreased satisfaction to the burden of learning a new course management system along with the digital technologies at the time of the research study.

Although this study was limited by perceptual data, the sample size, and the inability to generalize the findings to a larger population, the researchers emphasized the trend in age-linked dynamics that affect technology use.\textsuperscript{16} Although some say it is common knowledge that younger generations are better at using technology than are older generations, Salajan et al believed that drawing a division between students and instructors might be more damaging than helpful in promoting a constructive learning environment that is conducive to student-teacher rapport.\textsuperscript{16}

**Face-to-Face vs Online Classrooms**

Although researchers argue that younger generations are competent technology users and can transfer their digital skills to the online classroom, some studies suggest that digital skills in the academic setting are not so automatic.\textsuperscript{16-19} Gros et al hypothesized that positive perceptions of technology-supported learning are not related to whether a student belongs to a technologically savvy generation; rather, perceptions are influenced mainly by the teaching model (face-to-face vs online education).\textsuperscript{17} To analyze students’ perceptions of information and communication technologies for learning, the researchers distributed questionnaires to a random sample of 1042 younger-generation students (generations X and Y) and older-generation students (baby boomers) at 5 universities that provided either face-to-face education or online courses.

The results showed that baby boomer students in the online environment responded well to the course requirements and demonstrated competent digital skills, suggesting that the educational approach, whether face-to-face or online, is a stronger influence than generation type on students’ perceptions of the usefulness of technology-supported learning.\textsuperscript{17} Given their findings, the researchers suggested the need to consider how technology-rich learning environments can help develop students’ digital competencies, and not the other way around.\textsuperscript{17}

**Facebook Use**

Although Facebook predominantly is known as a site where family and friends can connect, it also is considered a valuable educational tool because it enables peer feedback, interaction, and learning in a social environment.\textsuperscript{20} Manca and Ranieri identified 5 main educational uses of Facebook\textsuperscript{21}:

- Supporting class discussions and helping students engage in collaborative learning.
- Developing content.
- Sharing educational resources.
- Delivering content to expose students to extracurricular resources.
- Supporting self-managed learning.

Using Facebook as an educational tool is relatively new, and little research exists regarding its benefits and challenges.\textsuperscript{20} To obtain descriptive statistics about the use of Facebook among college students, researchers conducted an exploratory study among 200 undergraduate psychology students, the majority of whom were members of generation Y. Of these, half were second-year students, and half were third-year students.\textsuperscript{20} Chi-square tests were performed to determine whether any differences existed between the 2 cohorts.\textsuperscript{20} The results suggested that most of the student participants were satisfied with Facebook and mainly used it to overcome boredom.\textsuperscript{20} All third-year students had a Facebook account, but only 65% of the second-year students acknowledged having a Facebook account. Students cited a lack of interest and an unwillingness to post personal information online as reasons for not having an account.\textsuperscript{20} Incidentally, the researchers concluded that the number of Facebook users and time spent online increase with younger-generation college students, making this social media site a potential educational tool.\textsuperscript{20}

Given the limited sample size of this study, which involved only 1 higher education institution, future studies with more participants and that collects qualitative data are warranted. Qualitative data would provide student and instructor perspectives on education and social media use and would help identify any advantages or disadvantages associated with using social media. Researchers also recommended analyzing other social media sites such as Twitter and Instagram.
Workplace Behavior

Generational differences in the workplace can present potential benefits and challenges for organizations, particularly for managers and supervisors. Rather than relying on anecdotal evidence and broad assumptions, social scientists are accumulating empirical data regarding specific workplace behaviors of each generation. These studies not only have implications for recruitment, hiring, and retention, but also provide managers a basis for developing teamwork strategies.

Hiring and Turnover

Based on the work-related behaviors of baby boomers, generation X, and generation Y, Becton et al tested 3 hypotheses in their research study:

- Baby boomers will display fewer job mobility behaviors than will generations X or Y.
- Baby boomers will exhibit more occurrences of compliance and experience fewer instances of termination than will generations X or Y.
- Generation X will report less enthusiasm to work overtime than will baby boomers or generation Y.

To test these predictions, the researchers assessed the feedback of 8040 applicants at 2 organizations. Job mobility was measured by asking the applicants to specify the longest amount of time they spent at 1 job and how many jobs they held in the past 5 years. Compliance behaviors were measured by asking the applicants how their most recent supervisor would rate their attendance and their adherence to dress code policies. Terminations were assessed by asking the applicants how many times they had been fired. Finally, enthusiasm to work overtime was measured by asking the applicants how often their most recent supervisor would say they were willing to work overtime.

The results provided full support for the first and third hypotheses and partial support for the second hypothesis. Regarding the first hypothesis, baby boomers spent an average of 73 months as the longest time spent at 1 job, with an average of 2 jobs held in the past 5 years; generation X averaged 49 months as the longest time spent at 1 job, with 3 jobs in the past 5 years; and generation Y averaged 23 months as the longest time spent at 1 job, with 3 jobs held in the past 5 years. Certainly, it could be argued that baby boomers have been working for a longer period of time than have generations X or Y.

All 3 generations gave themselves high ratings for attendance and dress code compliance, but the baby boomers scored themselves the highest. Baby boomers also had the highest termination percentages, which could be attributed to having more years of work experience than generations X or Y. When asked to work overtime, 44% of baby boomers reported a willingness, 38% of the generation X cohort reported a willingness, and 41% of the generation Y cohort reported a willingness.

Although the results of the study indicated some generational differences do exist in the workplace, the size of the differences for each generation in this study was small. In addition, the popular assumptions concerning each generation were not always consistent with respect to workplace behavior. The researchers acknowledged the study was limited because the data were self-reported.

Work Ethic

Observing an increase in turnover rates among baby boomer, generation X, and generation Y nurses at an inpatient acute care facility, Jobe examined the increase to see whether it was directly related to the work ethic attributed to each generation. Specifically, Jobe measured 7 dimensions of work ethic:

- Self-reliance: striving for independence in one’s daily work.
- Morality/ethics: believing in a just and moral existence.
- Leisure: emphasizing nonwork activities.
- Hard work: believing in the virtues of hard work.
- Centrality of work: believing in work for work’s sake and the importance of work.
- Wasted time: having attitudes and beliefs that reflect active and productive use of time.
- Delay in gratification: being oriented toward the future and the postponement of rewards.

Of the 285 completed surveys, the data suggested work-ethic similarities among the 3 generational cohorts with statistically significant intergenerational differences related to leisure, hard work, and delay of gratification. Generations X and Y, for example, placed more emphasis on leisure activities and hard
work than did baby boomers. This finding varied from the traditional view that younger generations are lazy. Generations X and Y also focused more on future career plans and delaying rewards than did baby boomers, possibly because baby boomers are nearing retirement and deferring rewards is no longer necessary to achieve their goals. Jobe recognized that changes in work ethic dimensions could lead to strategies for improving generational conflict and decreasing job turnover rates.

A study assessing generational differences in workplace ethics and turnover intention found significant differences between generation Y and baby boomers regarding emotional exhaustion, job satisfaction, and turnover intention. As expected, individuals from generation Y indicated significantly lower job satisfaction and higher turnover intentions when they were exhausted than did baby boomers. These findings might be the result of differing interpretations of the state of emotional exhaustion and different perceptions of work centrality among the generations.

Known to place more importance on work-life balance and leisure, generation Y might attribute their emotional exhaustion to the job itself because they do not value work more than their personal life and leisure time. Conversely, baby boomers might be willing to endure emotional exhaustion because they highly value their job and workplace ethics. In addition, baby boomers place their current position and job as top priorities, whereas generation Y members might be willing to try other positions before deciding on an ideal career.

The researchers were surprised not to find significant differences between generation X and the other generations regarding job satisfaction and turnover intention. This result might be because generation X individuals share distinct similarities with members of both generation Y and baby boomers. Generations X and Y highly value work-life balance and are not very loyal; on the other hand, generation X’s approach to their careers is similar to that of baby boomers.

Because this study was based on data from 1 branded hotel management company, its limited sample size cannot be generalized to other populations, including health care professionals. In addition, the researchers acknowledged having more female than male respondents, and they did not consider the possibility of gender partiality in responses. However, given that younger employees have lower job satisfaction and higher turnover intentions compared with older employees, the researchers stressed that managers need to consider implementing strategies (eg, flexible hours and adequate supervision) to address work-life balance for those younger employees.

**Expectations**

Newly licensed registered nurses from 3 generational cohorts (baby boomers, generation X, and generation Y) were surveyed regarding their work-related experiences, including their general characteristics and attitudes. Of the 2369 nurses in the sample, 251 (10.5%) were baby boomers, 1643 (68.8%) were generation X, and 465 (19.4%) were generation Y. The researchers examined their work attitudes, attributes, and demographics, as well as their job satisfaction, organizational commitment, job search, and intention to stay in a job. No statistically significant intergenerational differences existed concerning intention to stay and job-search behavior. Incidentally, approximately two-thirds of the nurses in each generational cohort were employed in the same position as the previous year. However, findings revealed significant differences among generations in several other areas:

- Baby boomers reported higher work motivation than did generations X and Y.
- Generation X demonstrated the highest levels of work-to-family conflict (the degree to which employment hinders family life) and family-to-work conflict (the degree to which family life interferes with work).
- Generation Y had greater levels of commitment to the organization, higher perceptions of promotional opportunities, and mentor and supervisor support than did baby boomers or generation X cohorts.

Unlike generations X and Y nurses, baby boomer nurses reported that they did not complete an employee orientation program, possibly because they were older and might have been perceived as less in need of a formal orientation program. Orientation is a vital part of new nurses’ adjustment to their organizations and their recognition in the profession. Compared with the
other generations, a higher percentage of baby boomers worked in jobs other than as staff nurses. A much lower percentage of baby boomers worked in intensive care units, but reported higher work motivation than did generations X and Y. It could be inferred that the baby boomer nurses in this study were better prepared to move into management positions although they were new graduates.

Nurses from generation X rated higher in work-to-family conflict and family-to-work conflict than did the other groups. As expected, those from generation X struggled with finding a balance between home and work life. Those from generation Y reported greater organizational commitment and were more likely to work 12-hour shifts and the night shift than were the other generations. Nurses from generation Y also expressed the importance of training with an experienced mentor and receiving support from direct supervisors.

As organizations continue to provide and improve orientations for newly licensed nurses, it is important to mold these programs to support nurses at the start of their careers and encourage their ongoing commitment to the profession. Although this study focused on nursing graduates, these findings are applicable to new radiologic technologists and radiation therapists. Managers of medical imaging and radiation therapy departments should invest time and effort into providing new graduates and new hires with adequate training and orientation that clearly state work expectations and encourages a commitment to the organization and profession.

To evaluate the importance that different generational cohorts place on specific workplace factors, Mencl and Lester distributed a survey to 636 employees aged 18 and older across government, health care, manufacturing, technology, real estate, and nonprofit organizations. The researchers analyzed data from a final sample size of 505 respondents who represented 3 generations (baby boomers, n = 273; generation X, n = 144; and generation Y, n = 88). The survey focused on 10 workplace factors:
- Involvement in decision making.
- A financially rewarding job.
- Work-life balance.
- A climate of diversity.
- Continuous learning.
- Career advancement.
- Immediate feedback and recognition.

All 3 generations placed importance on 7 of 10 workplace factors, demonstrating that the generations were more alike than different. The findings suggested the most significant generational differences concerned career advancement opportunities, which generation Y valued more than did generation X and baby boomers. The training and development value and the decision-making value also were statistically significant for generation X and baby boomers.

Although this study suggested that more similarities than differences exist among the generational cohorts, a limitation of the research was the unequal group sizes. The researchers recommended using the same group size for each generational cohort in future research. One key implication of these findings is that managers need to be educated and informed about generational differences and similarities rather than making assumptions.

**Teamwork**

Effective teamwork can be fostered in an environment that acknowledges the values, talents, and work ethics of each generational cohort. Several research studies documented generation X preferences for working alone. One study examined the attitudes of baby boomers and generation X on team formation. Using a survey design, the researchers discovered that members of generation X were more competitive, independent, and had a greater preference for working alone compared with baby boomers. In another study with similar results, baby boomers were more comfortable working with others and favored teamwork more than did generation X. Medical imaging and radiation therapy managers should inquire whether generation X employees prefer working alone or with others when assigning workload and other tasks.

When team members do not respect and value one another’s generational differences, conflict, distress, and incivility are unavoidable. Leiter et al collected
survey responses from more than 500 nurses to analyze the effects of generational differences and the implications for establishing a healthy work environment that promotes teamwork and good retention rates. The cohort sample represented baby boomers and generation X. Survey responses revealed that generation X experienced more incivility from coworkers and supervisors and overall higher levels of distress compared with baby boomers. The researchers concluded that negative social encounters at work contributed to nurses’ distress and suggested conflicts in values occur between baby boomer and generation X team members. Future research is warranted to include generation Y perspectives and contributions to teamwork.

**Patient Care**

Each generational cohort brings benefits to patient care within a health care organization. Growing up in an era when technology was not available, most veterans and baby boomers are aware of subtle cues and changes in a patient’s status long before a monitor or test shows patient deterioration. This type of experience bolsters veteran and baby boomer health care providers as experts in their respective departments. Conversely, generations X and Y grew up using technology and therefore can act as resources and assist older generations with better understanding and using technology in patient care. Overcoming generational differences among health care teams is important because generational issues can result in poor patient care, poorer outcomes, unsafe patient conditions, and decreased patient satisfaction.

Generational differences also can affect how patients perceive their care. Veteran or baby boomer patients might expect face-to-face communication from physicians, nurses, and other health care professionals, whereas generation X and Y patients might prefer to have electronic communications rather than face-to-face interactions.

One research study questioned whether generation was more caring than another based on an emotional intelligence proficiency. The results did not indicate substantive differences in emotional intelligence among the baby boomer, generation X, and generation Y nurses. However, the researchers noted that individuals from younger generations often required additional training on how best to communicate face-to-face. Finding ways to help younger generations become more comfortable with this type of communication is key to ensuring adequate patient care.

**Perceptions of Other Generations**

In a study by Gursoy et al that explored how each generation perceives the other generations, managers from the baby boomer generation expressed a very low opinion of generations X and Y. They believed the younger employees had no work ethic and considered them to be slackers. Baby boomer employees did not have very high opinions of their generation X managers. They indicated the generation X managers did not have the experience to lead, did not respect the baby boomers’ life experiences, and relied too heavily on technology.

Generation X managers did not think highly of generation Y employees. They considered them to be slackers, but admitted that they were very quick learners. Generation X, however, had very high opinions of their generation X managers. They indicated the generation X managers did not have the experience to lead, did not respect the baby boomers’ life experiences, and relied too heavily on technology.

This study relied on focus group sessions among a small group of hotel employees for data collection. Although 10 focus group sessions were conducted, findings cannot be generalized beyond the scope of this study. Descriptive statistics and data collected from a sample of health professionals might be beneficial for future studies involving generational differences.

**Challenges**

Some scholars have acknowledged the difficulty with defining generations. As stated previously, no official years mark the beginning or end of a generation.
with any social construct (eg, race, gender, ethnicity), boundaries are debated, and differentiations change with time and circumstances. Costanza and Finkelstein stated that generational cohorts are influenced by pivotal U.S. events and the assumption is that these events affected individuals in the same way no matter where they were geographically. They believed this might provide better research on generational differences and might explain conflicting results in previous studies.

A lack of theory to support generational differences also presents a challenge. However, Cadiz et al argued that methodological limitations, such as small sample sizes, guide research, not a lack of theory. They mentioned several theories to support the concept of generational differences: social forces theory, social identity theories, and lifespan development theories. However, Cadiz et al believed the way generational cohorts were examined in the literature is flawed. They suggested that a study involving generational differences is only helpful if the following conditions are met:

- The idea of being part of a specific generation becomes a part of people’s social identity.
- A generation is identified with specific events that truly have a formative effect on people.
- Reciprocal influences and exchanges within and between generations are studied along with the differences.

An Alternative Approach

Wang and Peng proposed an alternative approach to understanding generational differences specific to conducting organizational research. They suggested allowing the participants to decide which generation they identify with. Using a survey, checklist, or open-ended questions, the participants could rate the extent to which they identify with each category or statement. An analysis of their responses would allow researchers to classify the participants accordingly and proceed with their original research. Rather than being associated with a generation based on a birth date, Wang and Peng believed this might provide better research on generational differences and might explain conflicting results in previous studies.

Stereotypes

Another challenge related to generational differences in the workplace is the idea of publicizing generation-based stereotypes at work. Internalization of generational stereotypes could cause problems for individuals and organizations. Research has shown that stereotyping in the workplace results in negative job attitudes, poor mental health, and greater intentions to resign. Negative metastereotypes—what a particular group believes those in other groups think about them—also can be exacerbated. Metastereotypes related to generational differences could cause individuals to overcompensate to challenge the stereotype they believe others hold about them. To counteract these negative stereotypes, the focus should build on the positive aspects of diversity and on developing a more inclusive work environment.

Costanza and Finkelstein acknowledged that stereotypes exist because people from one particular generation do not share the same qualities, personalities, and values as members of other generational cohorts. For example, the veteran generation is stereotyped as being conservative and disciplined. These individuals grew up during the Great Depression, which is thought to have instilled in them values of frugality and hard work. Most would agree that this is a logical outcome; however, not all people who emerged from tough financial times embraced frugality. As an example, Costanza and Finkelstein discussed veterans who achieved success later in their adult lives, spent money impulsively, eventually declared bankruptcy, and ended up living in poverty again.
To address stereotypes associated with generation Y, Rentz conducted a mixed-methods study using surveys and focus group sessions. He discovered that this generation defied some of the general stereotypes associated with their generation but exhibited some stereotypical features as well. Contrary to common complaints about their poor work ethic, managers rated generation Y employees as having high standards, working hard, following through, and being realistic about rewards and raises. They also accepted criticism, did not require extra praise, took initiative, and were self-directed and resourceful.

Rentz also documented support for certain stereotypes associated with generation Y. These included leveraging technology, having a strong interest in what it takes to succeed in the company, being less interested in employee news and other facets of the big picture, and having an inflated sense of some of their abilities. Because generational stereotypes exist, Rentz suggested it was important to teach employees about generational differences and promote a work atmosphere of respect where all generations can contribute and feel valued.

Despite the negative connotation, some scholars consider the use of such stereotypes as necessary and acceptable. When comparing human groups, whether it is men, women, ethnic groups, leaders, service workers, nurses, or generations, stereotyping can be helpful and is expected. In almost every case, variances in traits exist within a group, and in most cases, the differences within the group are larger than the variances between groups. In addition, although stereotypes are key to understanding perceptions and identity in organizations, some researchers substitute the word stereotype with the more neutral term prototype to minimize the negative connotation.

**Generation-based Discrimination**

The general perception that differences among individuals relate to specific generational cohorts can pose some risk. Although it is tempting to consider these generational stereotypes as innocent misperceptions, they might, in fact, be quite harmful. Although age discrimination is prohibited by law, discrimination based on generational differences is not explicitly prohibited. Cox and Coulton noted that older individuals are offered some protection by the Age Discrimination in Employment Act; however, generation Y individuals are too young to qualify for legal protection. Thus, it is not clear what would happen if an employer terminated a younger employee based on his or her perceptions of generation Y. As expected, proving a termination decision was based solely on generational membership would be challenging.

Legislation that prohibits generation-based discrimination is unlikely, although considerable evidence shows that people refrain from making employment decisions based on stereotypes they believe are neither permitted nor appropriate. Cox and Coulton stated it was possible an enlightened supervisor might resist the temptation to ascribe behavior to age given the current legislation protecting older workers; however, the supervisor might feel that attributing behavior to generational differences is acceptable because legislation does not address the issue.

**Opportunities**

Generational challenges and stereotypes within an organization might abound, but positive opportunities also exist. A multigenerational team can be an asset to an organization. Each member brings unique strengths, viewpoints, and skills relative to his or her generational cohort. Health care leaders who have an understanding of generational differences and strengths can improve staff satisfaction and facilitate constructive working relationships to increase morale and productivity.

**Strategies to Increase Morale and Productivity**

Nelsey and Brownie stressed the importance of creating a work environment where employees, regardless of their generational background, feel supported and valued. They believed this work atmosphere could result in increased morale and productivity. Assessing a nursing workforce, they suggested providing generation Y nurses with opportunities for continual improvement and personal growth because these individuals tend to be ambitious and career focused. Nurse managers can provide generation Y staff nurses with opportunities to lead teams and attend professional development workshops that focus on career advancement and promotion. These opportunities would allow generation
Y nurses to feel important to the organization, and they potentially will work harder after receiving such recognition.

The researchers also suggested providing generation X nurses with opportunities to work independently on projects because nurses from this generation tend to be self-reliant and resist being micromanaged. Generation X nurses are less likely to view their supervisors in a negative manner when tackling self-directed tasks, and ultimately it can increase morale and productivity within the organization. Other general strategies managers can use to supervise generation X employees include:

- Providing staff incentives.
- Being supportive, trustworthy, professional, and dependable.
- Demonstrating good communication skills.
- Meeting regularly with staff members to provide feedback.
- Leading by example.

Nelsey and Brownie noted that an awareness of generational differences allows nursing managers to try various strategies to bridge those gaps, and they are likely to use the expertise of each group to optimize patient care and meet the needs of the organization.

**Mentoring**

Mentoring and continual support are essential to a new employee’s successful transition and professional growth, especially in the health care setting. Mentoring often is used to increase retention and decrease turnover rates. Nelsey and Brownie defined a skilled nurse mentor as one who assists new employees and less experienced staff by sharing clinical expertise and familiarizing them with the work setting. Of course, mentoring requires a commitment from both the mentor and mentee and is based on mutual trust, teaching, coaching, counseling, and friendship. Understanding generational differences and the common characteristics associated with each cohort can result in effective mentoring.

New nursing graduates from generation Y are professionally confident and outspoken yet require lengthy orientation and continual feedback as they make the transition to the clinical work environment. Baby boomers, with their superior clinical knowledge and extensive clinical experience, are well positioned to act as mentors and preceptors, in particular to younger generation Y nursing graduates. Mentoring is effective only when both the mentors and mentees earn mutual respect and benefit from the coaching process. In addition, because other research studies indicated younger generations train best with veterans, the possibility of veterans serving as mentors should be considered.

In organizations without formal mentoring systems, Nelsey and Brownie suggested encouraging new employees to seek mentors from other venues. In the health care setting, mentoring can help older employees feel valued by sharing their knowledge and expertise, and as mentees, younger generations can develop a sense of belonging and importance. Managers also can offer mentoring through one-on-one sessions, group programs, discussion panels, and roundtable discussions.

**ACORN Precepts**

ACORN (accommodate, create, operate, respect, and nourish) is an acronym for the 5 precepts or operational ideas used by successful companies to develop solid organizations. The use of these 5 precepts supports a generationally comfortable work environment where employees focus their energies on accomplishing the mission instead of on conflict. Table 2 explains each precept and provides an example of how managers can use these principles when dealing with a multigenerational department.

**Impact Within Radiology**

Because research pertaining to medical imaging and radiation therapy is extremely limited—most of the research pertains to radiologists—it is difficult to examine the effects of generational differences within the profession.

**Perceptions Among Radiologists**

The American College of Radiology (ACR) hosted a forum to discuss the effect of generational differences among practicing radiologists. Younger radiologists (generations X and Y) were perceived as being less committed to their profession than were prior generations. They more commonly viewed...
different generations to help foster a harmonious and productive radiology workforce.\textsuperscript{12}

**Job Satisfaction Among Radiologists**

Moriarity et al assessed generational differences related to workplace satisfaction and workplace characteristics among 1577 practicing radiologists from the baby boomer and generation X cohorts.\textsuperscript{43} Despite widely reported differences among generations, the findings indicated baby boomer and generation X radiologists shared similar characteristics.

Workplace satisfaction among baby boomer and generation X radiologists was 78\% and 80\%, respectively.\textsuperscript{43} Both generations indicated higher job satisfaction when they felt optimistic about the future of radiology, when they perceived a narrow difference between their desired and expected age of retirement, when they emphasized social interactions, and when they valued professionalism among their peers.\textsuperscript{43}

Baby boomer radiologists displayed greater job satisfaction when they worked in an environment that valued diversity, whereas generation X radiologists were more satisfied if they were paid well and worked in an environment that promoted job security.\textsuperscript{43} No significant association was seen between satisfaction and generation, sex, practice setting, or additional administrative work.\textsuperscript{43} The researchers concluded that workplace satisfaction among radiologists was high, and the 2 dominant generations of practicing radiologists had similar workplace satisfaction rates and preferred workplace characteristics.\textsuperscript{43} A research study involving radiologic technologists and radiation therapists is warranted to see if the results would be similar.

Table 2

<table>
<thead>
<tr>
<th>ACORN Precepts\textsuperscript{5}</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accommodating employee differences</td>
<td>Meeting the needs of employees by accommodating their unique preferences.</td>
<td>Allowing generation X employees to decide whether they want to work alone or on a team.</td>
</tr>
<tr>
<td>Creating workplace choices</td>
<td>Allowing the workplace to shape the work performed to serve customers and employees.</td>
<td>Using multiple modes of communication per employees' preferences.</td>
</tr>
<tr>
<td>Operating from a refined management style</td>
<td>Providing specific goals and measures to achieve and allowing employees freedom to complete the tasks in their chosen manner.</td>
<td>Verbalizing work expectations and providing new hires with adequate orientation.</td>
</tr>
<tr>
<td>Respecting competence and creativity</td>
<td>Assuming the best from all employees (from new staff members to the most seasoned).</td>
<td>Providing ample time for veterans and baby boomers to accept change and use new technology.</td>
</tr>
<tr>
<td>Nourishing retention</td>
<td>Retaining employees by providing frequent feedback, rewards, and recognition; encouraging lateral movement.</td>
<td>Offering new hires mentoring programs and giving specific praise to generation Y employees.</td>
</tr>
</tbody>
</table>

nonworking hours as an opportunity to pursue vocational and family activities rather than an opportunity to advance their medical knowledge, clinical practice, or the profession.\textsuperscript{12} Older radiologists (veterans and baby boomers) believed this attitude potentially could compromise the strength and vitality of the radiology profession and professional organizations such as the ACR.\textsuperscript{12}

Veteran radiologists were described as hard working and sacrificial; baby boomer radiologists were identified as being workaholics and efficient; generation X radiologists were characterized as needing balance between home and work life and preferring flexible work hours; and generation Y radiologists were labeled as being goal oriented, collaborative, and multitaskers.\textsuperscript{43} In addition, veteran radiologists viewed work as an obligation, baby boomer radiologists viewed it as an exciting adventure, generation X radiologists viewed it as a contract, and generation Y radiologists viewed it as a means to an end.\textsuperscript{13}

Ultimately, the ACR thought it was critical to appreciate the varied needs, desires, and motivators of
Managing Multiple Generations in the Workplace

Leadership Tactics

As leaders of the department, managers need to understand each generation, recognize the generation they belong to, and use each group’s unique characteristics to their advantage. \(^1\) Facilitating employees’ growth and development is an important part of leadership; however, the presence of a multigenerational department makes this difficult to achieve. \(^4\) Medical imaging and radiation therapy managers are encouraged to lead multigenerational departments using the following tactics: \(^4\):

- Seek ways to understand each cohort and accommodate differences in attitudes, values, and behaviors.
- Cultivate generational strengths to motivate all employees in the department.
- Develop the ability to be more sensitive to the strengths and weaknesses of each cohort, especially in the area of technology advancement.
- Promote tolerance to avoid generational conflict and to enrich teamwork skills.
- Capitalize on generational differences to improve the overall quality of work and to enhance patient care outcomes.

Managing Veterans

In today’s struggling economy, many veterans have remained in the workforce. \(^1\) As previously mentioned, veterans like to be recognized for their years of service and experience. Pairing them with a newly hired young technologist can boost their morale and promote long-term benefits for the department as well. \(^2\) Veterans know a plethora of shortcuts and tips to achieve the perfect image during difficult procedures, and younger technologists can gain a wealth of information by learning from experienced technologists.

Considering the continual advancements in medical imaging and radiation therapy technology, veterans might need additional training when learning new equipment or software. Veterans are hard workers and will take the time to learn the equipment, software, and procedures even if they involve new technology. Individual support when learning how to operate new radiographic or therapeutic equipment also might be beneficial to a veteran radiologic technologist or radiation therapist. If applicable, radiology managers should modify a veteran’s job duties to accommodate his or her abilities.

In summary, Johnson and Johnson suggested the following tips for managing veteran employees: \(^4\):

- Make them mentors to younger employees.
- Provide training for new systems and procedures.
- Accommodate their needs.
- Recognize and applaud their contributions.
- Give one-on-one support.

Managing Baby Boomers

Although baby boomers are nearing retirement, they should not be shunted to the side and ignored until they leave. \(^4\) They have wisdom and experience that can provide valuable information for managers as they make important decisions about daily operations in the department. Like veterans, baby boomers feel valued and appreciated when they are given the opportunity to mentor a younger technologist. \(^2,42\)

Of course, with any mentoring relationship, mutual respect and trust are essential. \(^42\) Managers from younger generations are encouraged to lead baby boomers by respecting their experiences and service to the department, motivating them on their own terms, and arranging for recognition and credit. \(^4\)

Younger managers can prove themselves to baby boomer technologists and therapists by being a working manager and assisting with examinations and treatments during busy times or when short staffed. In summary, suggested tips for managing baby boomers include: \(^4\):

- Make them mentors.
- Do not ignore or give up on them.
- Ask for continuing contributions.
- Offer opportunities to volunteer.

Managing Generation X

Although generation X employees tend to seek individual recognition, this does not imply that they cannot or will not work well on teams. \(^4\) Johnson and Johnson argued that creating collegial teams where generation X employees work with colleagues to accomplish a common goal can benefit an organization. \(^1\) Providing a flexible work schedule can be a difficult task for medical imaging and radiation therapy departments; however,
managers should offer generation Y technologists and therapists flexibility in terms of work hours and schedule. In conclusion, suggestions for managing generation Y include the following:

- Create opportunities to bond.
- Offer mentoring, coaching, and guidance.
- Give praise that is specific, significant, and sincere.
- Provide constructive, specific criticism in private.

Preparing for Generation Z

Generation Z, also known as gen Z, tGeneration, and linksters, were born after 2000. An estimated 23 million people in the United States compose this generation, and the group is growing. Most of the characteristics that define this generation have yet to emerge; however, because they have been exposed to digital communication and technology throughout their lifetime, they are described as being highly connected. They tend to interact electronically more than personally, and they might choose to text message someone even if they are standing next to him or her. The Box lists some of the historical and social events experienced by generation Z individuals.

Although young, it appears that generation Z will mobilize around causes and be more socially and environmentally aware than previous generations. Many older individuals from generation Z are beginning to enter the workforce, and they are the most technologically savvy of any generation. They are connected to their peers through social media, are intelligent and have higher IQ scores than members of previous generations, and generally are accepting of diverse populations. This is the largest home-schooled generation, and they require less direction and supervision because

Managing Generation Y

Generation Y employees have different work requirements and expectations than do their baby boomer and generation X managers. Understanding these differences helps managers to be effective and their generation Y employees to flourish. By creating opportunities to bond, radiology managers can provide generation Y technologists with the rapport they are accustomed to with their teachers and parents. Johnson and Johnson stressed that managers should insist generation Y employees follow the rules, complete their tasks, meet their deadlines, and produce quality work. If they meet goals, managers should applaud them for their service. If not, managers should help, coach, encourage, and even counsel them to establish that bond so generation Y employees know what is expected of them.

Medical imaging and radiation therapy managers should check in with generation Y technologists and therapists daily, offering praise when deserved and providing corrective feedback when needed. Managers also should communicate specific work expectations; generation Y employees need to be aware of what is expected of them and what their responsibilities are. If possible,
they already have access to digital tools that enable them to do almost anything.\textsuperscript{6}

Members of other generations must be able to work with and adjust to generation Z’s changing social skills that are driven by advancing technologies.\textsuperscript{4,5} This generation can present themselves as an open book with very little concern about sharing private and personal matters. Like generation Y, individuals from generation Z are close to their parents and consider them to be their best friends.\textsuperscript{4}

As more generation Z members enter the workforce, they easily can handle job requirements that involve technology but will have a tougher time with face-to-face communication with customers and coworkers.\textsuperscript{4} In addition, as higher education becomes more cost prohibitive, generation Z will seek alternative ways to enter their preferred, chosen professions.\textsuperscript{8}

**Conclusion**

Multiple generational cohorts coexist in the workplace today. Each group brings different viewpoints, expectations, desires, dreams, values, and ideas about work and life. For health care organizations, these generational differences can enhance teamwork and improve patient care; they also can present challenges such as conflict and stereotyping. By understanding generational differences, managers and organizations can foster a work environment that embraces diversity and promotes productivity. Because very little research on generational differences in the radiology workplace has been conducted, research specific to the medical imaging and radiation therapy professions is warranted.

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Managing Multiple Generations in the Workplace

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

1. Which of the following describes the environment baby boomers grew up in?
   - steady state of free expression
   - economic prosperity
   - world wars
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

2. Which generation dislikes direct supervision and resists micromanaging bosses?
   a. veterans
   b. baby boomers
   c. generation X
   d. generation Y

3. Which generational cohort represents the largest group of workers in the U.S. workforce today?
   a. veterans
   b. baby boomers
   c. generation X
   d. generation Y

4. In the study by Becton et al, which generational cohort scored themselves the highest with respect to attendance and dress code compliance?
   a. veterans
   b. baby boomers
   c. generation X
   d. generation Y

5. In the study by Mencl and Lester, which workplace factor resulted in the most significant difference among the generational cohorts?
   a. career advancement opportunities
   b. involvement in decision making
   c. work-life balance
   d. continuous learning
6. Which statement is **true** regarding the study by Gursoy et al on perceptions of other generations?
   a. Baby boomer managers believed younger generation employees had a strong work ethic and considered them to be hard workers.
   b. Baby boomer employees did not have high opinions of their generation X managers.
   c. Generation X managers thought highly of generation Y employees.
   d. Generation X managers said baby boomer employees were fast learners and good with technology.

7. Proving a termination decision was based solely on generational membership would be challenging.
   a. true
   b. false

8. Strategies to increase morale and productivity among generation X employees include:
   1. providing staff incentives.
   2. being supportive, trustworthy, professional, and dependable.
   3. leading by example.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

9. The American College of Radiology determined which generation of radiologists considered work to be a contract?
   a. veterans
   b. baby boomers
   c. generation X
   d. generation Y

10. Which generation of radiologists displayed greater job satisfaction based on job security and good compensation?
    a. veterans
    b. baby boomers
    c. generation X
    d. generation Y

11. Which of the following are strategies for leading veteran employees?
    1. using electronic communications such as email
    2. providing training for new procedures
    3. giving one-on-one support
    a. 1 and 2
    b. 1 and 3
    c. 2 and 3
    d. 1, 2, and 3

12. Which of the following describe generation Z?
    1. beginning to enter the workforce
    2. intelligent with high IQ scores
    3. the most technologically savvy generation
    a. 1 and 2
    b. 1 and 3
    c. 2 and 3
    d. 1, 2, and 3
Directed Reading Evaluation
Managing Multiple Generations

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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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Managing Multiple Generations in the Workplace

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Anorexia nervosa is a psychological disorder with extensive physical complications that require care and monitoring from a diverse team of health care professionals. Although it can affect people of various ages and both sexes, anorexia most frequently occurs in adolescent girls during a crucial period of skeletal development. This article presents an overview of anorexia nervosa, followed by focused discussions of its effects on bone development, treatment of bone loss, and the radiologic technologist’s role in caring for anorexic patients.

After completing this article, the reader should be able to:
- Discuss risk factors for and the presentation of anorexia nervosa.
- List anorexia’s effects on various body systems.
- Describe changes in normal bone development caused by anorexia.
- Compare treatment options for age-related vs anorexia-induced bone loss.
- Explain the importance of the bone densitometry technologist in anorexia treatment and monitoring.

A certain patient stereotype likely comes to mind when discussing bone density or dual-energy x-ray absorptiometry (DXA) examinations: a somewhat feeble, elderly woman, attempting to stave off the natural decline that comes with age. Although most patients receiving bone density monitoring or treatment fit this stereotype, medical professionals should be aware of and prepared for a variety of patient types. Advances in bone densitometry technology and understanding of various conditions have expanded vastly the use and application of bone density measurements. Most notable have been expansions into care of pediatric and young adult patients, diagnosing and monitoring conditions that affect physical development, and helping to identify nutritional deficits.

Bone density examinations can be used to diagnose primary osteoporosis in children due to juvenile idiopathic osteoporosis or osteogenesis imperfecta. They also can be used to monitor conditions that result in secondary bone density changes, such as Cushing syndrome, hyperthyroidism, hypogonadism, and sickle cell anemia. Although many conditions are seen primarily in practices that specialize in a specific age group or type of underlying condition, other conditions should be familiar to all technologists working with bone densitometry. Eating disorders fall into that group because they can affect patients in a range of ages and without connection to an underlying physical illness. All technologists should understand what is happening to a patient with an eating disorder and how to provide the best possible care. Restrictive eating disorders have unique presentations, histories, and comorbidities that must be appreciated.

Nutrition

Nutrition plays a vital role in body development throughout infancy, childhood, and adolescence, and it directly affects proper functioning throughout
life. Healthy bone development and maintenance are most directly associated with adequate intake of calcium and vitamin D, along with vitamins A and C; both insufficiency and excess can cause predictable maladies. Indirectly, nutrition’s effects on weight, hormone secretion, energy, susceptibility to illness, and other aspects of overall health influence bone development.

The importance of nutrition begins even before birth, with the mother’s nutrition directly affecting early development and setting the stage for growth and development continuing into adulthood. The mother’s consumption of dairy products and vitamin D during pregnancy has been shown to have a direct correlation with fetal bone development and bone density in children into their teens. Lack of proper nutrition can cause intrauterine growth retardation and places infants at a deficit from which it can be difficult to recover, leaving them prone to type 2 diabetes mellitus, hypertension, stroke, and coronary artery disease later in life.

As infants and children change, so do their nutritional needs and susceptibility to various conditions. Infancy and childhood are marked by steady growth and development, requiring sufficient energy sources to support these processes and the essential building blocks for normal development to occur. Required caloric intake for active children increases from approximately 1000 calories per day at 2 years old to approximately 2000 calories per day or higher as children approach adolescence. Calcium and vitamin D are vital for the skeletal system, with recommended allowances for calcium ranging from 700 mg per day for toddlers up to 1000 mg per day for older children; vitamin D recommendations stay mainly consistent at 600 IU per day until a slight increase later in life.

Growth rate further accelerates during puberty and adolescence, reaching its peak and creating the highest nutritional demands within the lifespan. Caloric intake for moderately active boys and girls is highest during this time, with recommendations of approximately 3200 calories per day for boys and young men aged 16 to 18 years and approximately 2400 calories per day for girls and women aged 14 to 30 years. The daily calcium allowance increases to 1300 mg per day for people aged 9 to 18 years, the highest level of any point in a healthy lifespan. Calcium retention is also highest during adolescence.

In adulthood, once peak development has been reached, the body shifts to maintenance. Necessary caloric intake declines slowly but consistently after its peak and into old age. Calcium retention is lower than during adolescence or childhood, and the dietary calcium allowance decreases to 1000 mg per day after adolescence. Unlike caloric intake, however, calcium requirements change again later in life, increasing to 1200 mg per day for women older than 50 years and for men older than 70 years, as the bones begin to lose density and require additional calcium and vitamin D to maintain mass. After age 70, the daily allowance of vitamin D also increases to 800 IU per day.

Malnutrition

If the necessary amounts of nutrients are not consumed, development and function are hindered. Prolonged vitamin C insufficiency leads to scurvy (abnormal bone development in infants and children and swollen, painful joints) and reduced ability to fight infection or heal following injury. The body generally eliminates excess vitamin C through the urine, although consistently high levels of the vitamin can be harmful in certain circumstances. For example, an infant can develop symptoms of scurvy when the daily dose of vitamin C after birth is lower than exposure in the womb because of the mother’s high intake of ascorbic acid during pregnancy. High levels also can exacerbate gout and kidney stone formation.

Insufficient vitamin D results in rickets (failure of bones and teeth to develop normally) in children and osteomalacia (softening of the bones due to decalcification) in adults. Because vitamin D is fat soluble, excess also can be unhealthy, leading to diarrhea, nausea, weight loss, kidney damage, and calcification of soft tissues.

Lack of adequate vitamin A interferes with normal bone growth and development, as well as causing night blindness, xerophthalmia (dryness of the conjunctiva and cornea), degeneration of certain epithelial tissues, and susceptibility to infection. Because it is also fat soluble, excess vitamin A can be detrimental, causing peeling skin, hair loss, nausea, headache, birth defects, inhibited bone growth, and increased risk of fractures.

Insufficient calcium leads to stunted growth and misshapened bones in children and thinning bones and
higher fracture risk in adults. Calcium deficiency also can cause tetany (involuntary muscle cramps) when nerve function is affected. However, too much calcium can lead to calcium phosphate deposits in soft tissue or kidney stones. A proper balance of other nutrients, vitamins, and minerals is required for growth and development of all tissues and structures and efficient body function throughout life. Failure to maintain a healthy diet can result in a wide range of substance-specific disorders, malnutrition, and even starvation.9

When nutrition is poor, it is important not only to identify what is out of balance but also to determine the cause. Malnutrition can result from either undernutrition (deficiency in consumption or use of nutrients) or overnutrition (overeating or overuse of vitamin supplements). Primary malnutrition occurs as a direct result of diet alone. Secondary malnutrition occurs when an otherwise healthy diet is not sufficient for a particular individual because of an underlying medical condition or lifestyle. Starvation results from prolonged lack of nutrition, causing discernable changes in body function and metabolism. Body functions slow down to conserve energy, and the body begins to digest itself to preserve essential life functions as long as possible. Unresolved starvation eventually leads to death and can result from lack of resources (eg, extreme poverty), conscious choice of deprivation (eg, a hunger strike), or an eating disorder.9

An eating disorder occurs when an individual’s failure to maintain healthy nutrition is the result of psychological, rather than physical or environmental, causes. It is not the same as malnutrition due to lack of access to nutrients or constraints imposed by an outside force and is not a choice. An eating disorder might involve unhealthy overeating, losing the ability to regulate food intake, and even eating when uncomfortably full. Alternatively, a disorder can be restrictive, for example, if the person becomes preoccupied with controlling food intake and weight to the point of interfering with normal activities and nutritional detriment. This might involve overly strict control of calorie intake, attempts to rid the body of calories (through exercise, laxatives, or vomiting), or both. Eating disorders generally are connected to distortions in body image, perception of weight, self-worth, and control. Sufferers of all types of eating disorders—even if they are aware of their condition—believe they do not have a choice or control over their actions.9

Although people of varying ages, both sexes, and all backgrounds can have an eating disorder, some groups are affected more frequently, and certain risk factors are associated with a higher susceptibility. Girls and women are more likely to experience an eating disorder in their lifetime, with most cases occurring during adolescence, a crucial period of rapid physical development.10,11 Because of this commonality of demographic factors, the majority of anorexic patients present with common complications and comorbidities. Other risk factors include having a family history of eating disorders and having depression, obsessive-compulsive disorder, or another mental condition. In addition, excessive stress and intense pressure from coaches, parents, or others can contribute to the development of eating disorders. All these factors should be taken into consideration during treatment.10,12

Eating Disorders

Symptoms and complications of eating disorders vary from person to person, and each individual must be treated as a unique case; however, the fifth edition of the American Psychiatric Association’s Diagnostic and Statistical Manual of Mental Disorders provides guidelines for making a diagnosis. There are 3 primary groups of disorders and a fourth category for individuals who do not fully meet the criteria for a specific condition. Conditions can be classified as anorexia nervosa, bulimia nervosa, or binge eating disorder (BED).13,14

Anorexia can be purely restrictive, such as when the patient attempts to avoid calories and possibly rid the body of calories through fasting or overexercising to “justify” eating. It also can include periods of binging, when the patient feels a loss of control over his or her ability to avoid eating, and purging, when the patient attempts to undo the “damage” of eating, with an overall loss of weight. Patients with anorexia lose weight to the point of starvation while obsessing over a perceived need to lose more weight and reduce food intake. They become thin, with distorted perceptions of their bodies. Patients diagnosed with bulimia feel a loss of control over eating, alternating periods of binge eating with attempts to purge the body of food through induced
vomiting, laxatives, or overexercising. Symptoms might be similar to anorexia; however, these patients can appear to be of normal weight or even slightly overweight.

Understanding of BED and its acknowledgment as a defined eating disorder have expanded recently. BED differs from the previous 2 types of eating disorders in that it does not involve attempts to minimize caloric intake nor does it include purging calories. Patients with BED might be normal weight or overweight and are characterized by loss of control over food and feeling embarrassed or disgusted by their own behavior. They might be in denial over the amount of food they eat or attempt to eat in secret and hide their true intake. Other patients experience some distinct symptoms of eating disorders without meeting all the criteria for diagnosis and are therefore categorized as having an eating disorder “not otherwise specified.”

**Psychological Component**

Although each diagnosis is distinct, all are within the realm of mental disorders and reflect powerful underlying psychological elements. There is no single test to diagnose an eating disorder, nor a single medication or therapy to cure one. Diagnosis might require a physical examination, laboratory tests, and a thorough psychological evaluation to determine whether a problem exists and whether that problem results from purely physical causes or psychological components. A diagnosed eating disorder depends on an individual’s attitudes toward food and nutrition and could develop as an attempt to control overwhelming emotions or other aspects of life. Therefore, effective treatment begins with identifying and addressing the core issues. Many patients have signs of more than one condition; multiple disorders should be treated simultaneously for the best outcome. A long-term approach to mental well-being and correcting the root cause is necessary, or the disorder will persist.

**Physical Component**

Eating disorders attract the attention of medical professionals well beyond psychiatry because patients struggling with these conditions are prone to numerous physical manifestations that can severely affect development, quality of life, and even life expectancy. The restrictive nature of anorexia nervosa makes it the eating disorder most often assessed by bone densitometry. Although BED and bulimia affect bone density to some degree, the effects resemble those seen in other conditions. BED is similar to general obesity in spite of its psychological component; bulimia reflects dietary deficiencies. Anorexia, which is characterized by extreme weight loss, presents unique complications and the most severe changes in body composition and function. Eating disorders result in a higher mortality rate than other mental disorders, and anorexia is associated with the highest mortality rate of all.

Some effects of anorexia are obvious to people around the patient and can be noted on a physical examination by a physician. A key differentiation between anorexia and other eating disorders is significant weight loss below what is considered a healthy body mass index and, if untreated, to the point of starvation. Because of the associated weight loss, health care professionals are more likely to suspect a patient has anorexia based on physical appearance than BED or bulimia. Even to those not trained in health care, extreme weight loss can signal poor health and raise concerns. Many effects are not so readily visible, however, and add to the underlying disorder, causing further complications. Weight loss can affect hormone production and alter or stop menses. Both weight loss and hormone dysfunction can lead to poor bone development, bone loss, and increased risk of fracture.

Hair, skin, and nails change with malnutrition. Nails become brittle and easily damaged. Hair becomes dry, easily broken, and often, as a result of the extreme weight loss, begins to thin. Skin becomes dry and might be yellowish, especially on the palms, cuticles, and soles. These easily detected symptoms signal even more significant problems within the body. The yellowing skin, for instance, indicates significant slowing of the metabolism that causes accumulation of carotene that cannot be processed efficiently. A slowed metabolism is the body’s response to receiving fewer calories than needed to function, decreasing caloric usage in an attempt to survive potential starvation. The patient’s heart rate decreases, as does digestion, causing constipation. The patient also experiences fatigue and decreased tolerance of cold.
Anorexia poses serious hazards if untreated. Protein deficiency due to malnutrition and loss of lean weight can affect numerous vital functions and systems (see Figure 1). Protein deficiency can lead to electrolyte deficiency, impairing kidney function.\(^9,10\) Significant weight loss is associated with the depletion of heart, brain, and other organ tissue, in addition to low body temperature and decreased growth in adolescents. It promotes a slowed metabolism and the related complications. Impaired cardiac function and loss of cardiac muscle increase the risk of heart failure. Among patients with severe anorexia, 30% to 50% experience chest pain due to mitral valve prolapse from decreased heart size.

Loss of cardiac muscle results in decreased blood pressure and heart rate, which can in turn cause dizziness, fatigue, and cognitive impairment.\(^9,10\) Severe symptoms require hospitalization; left untreated, problems can become fatal.

Cerebral atrophy, especially in adolescents, creates notable deficits in cognitive, emotional, and social function. In people who have experienced extreme weight loss, computed tomography and magnetic resonance imaging show a reduced amount of gray and white matter and increased ventricle size.\(^15\) These changes interfere with decision making and interpersonal relationships. Problems are worst at the peak of anorexia, improving with recovery, but persisting somewhat even years later.\(^9,10\)

Assorted signs and symptoms result directly from hormonal changes. Gonadal hormones decrease in both sexes, causing decreased libido along with the possibility of amenorrhea and decreased ovulation in adolescent girls and women.\(^9,10\) Some improvement in menstrual symptoms can be seen with the use of oral contraceptives. Other possible dysfunctions include hypothalamic–pituitary dysregulation, hypothalamic amenorrhea, hypothalamic–pituitary–adrenal axis dysregulation, and hypothyroidism. Symptoms of hormonal changes can include sensitivity to cold, hypotension, increased cholesterol level, decreased fasting glucose level, and low heart rate. Retarded growth can occur during childhood or adolescence because of decreased growth hormones.\(^9\)

Hormone dysfunction, like other nutritional deficiencies, can negatively affect bone

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health at all stages of life.\cite{10} These changes to the skeletal system are of the greatest significance to the bone densitometry technologist.

**Normal Bone Development**

To understand how eating disorders affect the bones, it is important to consider normal bone formation and maintenance, which are complex processes that begin in the womb. In the early weeks of fetal development, the skeleton begins to grow from connective tissue and cartilage.\cite{16} Calcification and expansion continue throughout childhood and adolescence. Two types of ossification replace cartilage or fibrous tissue with bone: endochondral and intramembranous ossification.

Intramembranous bones are flat bones, such as the skull, mandible, and clavicles. During fetal development, these bones arise from layers of undifferentiated connective tissue. The connective tissue cells surround themselves in collagen fiber and differentiate into osteoblasts, forming an ossification center (see Figure 2). Osteoblasts are the cells responsible for the production of new bone throughout life. As the osteoblasts begin to secrete osteoid, some of them become isolated in the newly calcified bony matrix; these cells are known as osteocytes, or bone cells. The osteoid is deposited between the embryonic blood vessels, creating a random network of trabeculae. The growth and differentiation continue, producing broad, flat bones with spongy interiors encased in dense compact bone.\cite{16}

**Figure 2.** Intramembranous ossification follows 4 steps. A. Mesenchymal cells group into clusters, and ossification centers form. B. Secreted osteoid traps osteoblasts, which then become osteocytes. C. Trabecular matrix and periosteum form. D. Compact bone develops superficial to the trabecular bone, and crowded blood vessels condense into red marrow. © ASRT 2017.
Endochondral bones make up the majority of the skeleton. Long bones are formed on or within a hyaline cartilage model (see Figure 3). As the cartilage cells grow, they develop small cavities called lacunae before degenerating and leaving space for blood vessels and connective tissue cells to invade. Like intramembranous ossification, the cells further differentiate into osteoblasts and begin to deposit bony matrix around themselves. The osteoblasts trapped in the mineralized osteoid become osteocytes.\textsuperscript{16}

In long bones, ossification begins in the shaft, or diaphysis, which becomes the primary ossification center. Secondary ossification centers appear in the epiphyses at one or both ends of the bone. Epiphyseal plates of hyaline cartilage remain between the diaphysis and epiphyses; these plates allow continued expansion of the bone through growth. The plates expand outward, and osteoblasts invade the outer regions, secreting calcium salts and calcifying the cartilaginous extracellular matrix.\textsuperscript{16}

Osteoblasts eventually die, and osteoclasts move in to break down the matrix. Osteoclasts are multinucleated cells that secrete acids to dissolve inorganic components and enzymes to digest organic compounds. The osteoclasts break down central spongy bone, creating the medullary cavity and space for marrow. After the osteoclasts phagocytize the calcified cartilage, osteoblasts return to deposit new hard cortical tissue around the spongy bone. Bones continue to lengthen in this manner until the primary and secondary ossification centers meet, and the epiphyseal plates also ossify.\textsuperscript{1,16}

Once bones are formed and well before ossification is complete, osteoblasts and osteoclasts work simultaneously to remodel bones. Bone is broken down during resorption, and new bone is formed during deposition. The balance of these 2 processes is regulated carefully to produce growth when needed and maintain homeostasis when no change is warranted. Factors influencing the remodeling process include sunlight exposure, nutrition, hormones, and physical exercise.\textsuperscript{16} Each element ensures healthy development, and a problem in any area can disrupt normal growth.

Calcium is a key component of bone, a necessary building block to strengthen the bony matrix and prevent softening and deformity under pressure. Approximately 70% of bone weight is from inorganic material, and approximately 95% of this is calcium phosphate crystalline hydroxyapatite.\textsuperscript{17} Without vitamin D, calcium absorption is poor and calcium is not used efficiently, even if an adequate amount of calcium is consumed. Most vitamin D is consumed through eggs or foods fortified with vitamin D, such as milk,
but the body can use ultraviolet light from the sun to convert dehydrocholesterol produced in the digestive tract or consumed in the diet into vitamin D in the skin. Vitamin A is required for the function of osteoblasts and osteoclasts; a deficiency can therefore retard growth by slowing osteoblast activity. Collagen synthesis requires vitamin C for proper production; poor production in the extracellular matrix results in abnormally slender, fragile bones.²

Hormones that play a significant role in bone development are secreted by the pituitary gland, thyroid gland, parathyroid gland, and ovaries or testes. Growth hormone produced in the pituitary gland promotes cartilage growth in the epiphyseal plates. Without sufficient growth hormone, the long bones do not develop properly and pituitary dwarfism results. If excess growth hormone is secreted during childhood or adolescence, pituitary gigantism results, leading to extreme height. Excess growth hormone in adulthood results in acromegaly, which causes enlargement of the hands, feet, and jaw. Thyroxine, a hormone produced by the thyroid gland, stimulates production of bone tissue to replace cartilage in the epiphyseal plates. Excess thyroxine can halt growth, causing the plates to ossify prematurely. Thyroxine also stimulates secretion of growth hormone from the pituitary gland; without it, secretion slows, stunting growth. Parathyroid hormone has an opposite effect from thyroid hormones by stimulating the number and activity of osteoclasts to break down bone, hindering bone growth and maintenance, if present in excess. Testosterone and estrogen promote bone production and ossification, although estrogen has a stronger effect. Increased levels of sex hormones during puberty accelerate growth rate as well as the ossification of epiphyseal plates that stops growth.¹⁶

Even physical activity plays a role in bone development and growth. The pull of muscles on bones creates stress, generally at levels too low to be harmful, which in turn causes the bone tissue to thicken and strengthen to better handle the stress.¹⁶ In addition to physical stress, exercise has been found to promote the release of myokine irisin in skeletal muscles, which promotes strengthening and increased density of cortical bone.¹⁸ Frequent exercise, especially with weight training, forces bones to become stronger. Athletes typically have denser, stronger bones than otherwise healthy nonathletes with typical growth. Immobilization or other lack of exercise eliminates the opportunity to strengthen the bone and can cause atrophy to the point of thinning or shortening of the bone. According to Wolff’s law, physiologic or mechanical forces also influence the shape and orientation of bones during modeling to best meet the specific demands of the environment.¹⁷

**Peak Bone Mineral Density**

Bone development begins in the womb and continues throughout childhood and adolescence. Bones experience modeling with growth, adapting to physical needs and environmental influences with a net gain of bone tissue. Throughout these periods, bones do not grow at the same rate for all children and might not correlate with chronologic age. The degree to which bones are formed and epiphyses are fused can be used to determine bone age, a better reference for expected bone density throughout development than chronologic age. Because sex hormones greatly affect bone development, sexual maturation stage also can be used to establish a more accurate reference point. Evaluations of bone health and fracture risk must take into account these developmental factors and not make comparisons with adult norms.¹

Net bone growth occurs at a rate of approximately 3% to 4% per year for children and adolescents, after approximately 8 years of age.¹⁹ As the body reaches a certain point in growth and bones reach a certain length and size, signals within the body change to terminate the net gains. Bones, including growth plates, ossify to prevent further increases.

The point at which growth stops and bones are fully ossified closely correlates with the point of peak bone density. This is the point at which bone density is the highest it is expected to reach with healthy growth and should be comparable to averages for healthy adults of the same sex and size, and the reference point for determining future bone degradation. The exact age of peak bone mineral density (BMD) varies among skeletal sites and among individuals because of differing rates of development. For the average individual, peak BMD is not achieved until a few years into adulthood, around
the early 20s for women and slightly later, around the mid-20s, for men (see Figure 4).\textsuperscript{1}

**Maintaining Bone Mass**

Once peak bone mass is achieved, the body’s processes shift to maintenance and protecting against structural loss. Modeling is no longer common after the age of 20, when the individual has ceased growing. After this point, remodeling occurs constantly to maintain the structural integrity of bones and sustain the skeleton's role in regulating extracellular fluid composition. Bone resorption and bone formation occur simultaneously, with formation following resorption to provide replacement bone equal to that which is removed. Any disease process or nutritional deficit that impairs this balance results in a change in bone mass. For structural stability, a turnover rate of approximately 2\% to 5\% per year allows for repair and prevents fatigue damage. To maintain extracellular fluid regulation, a rate of approximately 15\% to 35\% per year is required, primarily in the trabecular bone of the axial skeleton adjacent to the red marrow. An increased or reduced bone turnover rate, even if no change in bone density is observed, is associated with increased risk of fractures.\textsuperscript{17,20,21}

**Normal, Age-related Bone Loss**

As the body ages, certain changes are anticipated. Even in otherwise healthy individuals, the cortex of bone thins over time, changing composition and density.\textsuperscript{17} Hormonal changes, especially the decline in estrogen after menopause, changes in activity level and diet, and increased disease and injury incidence all can affect bone density and structure with a measure of predictability. For this reason, bone density is not only compared with levels in healthy young adults, but also with age-adjusted averages, similar to studies in pediatric patients. Bone loss compared with the peak BMD is considered normal to a certain extent, and age-adjusted values decline with advancing years. Even substantial bone loss might be predictable based on certain traits or lifestyle choices. Some known risks for secondary osteoporosis include long-term use of glucocorticoids, a history of alcoholism, emphysema, epilepsy, hormone therapy for prostate cancer, and long-term heparin use, among many others.\textsuperscript{22} Changes due to normal aging—or from any of the risk factors for secondary osteoporosis—affect the integrity of the bones and increase the risk of fractures and complications from fractures, increasing mortality rates.

**Anorexia’s Effects on Bone Development and Maintenance**

For patients with eating disorders, especially anorexia nervosa, the normal progression of bone development and maintenance is hindered. The severity of the disorder, duration of symptoms, and stage in life at which it occurs influence the extent and reparability of the damage. During childhood, eating disorders are less likely to present with drastic loss of bone density than with failure to
gain at a typical rate. The decreased rate might be most evident in changes in height or weight. Longitudinal growth is stunted under the unfavorable conditions imposed by the eating disorder. Future growth might not fully compensate for these delays, although it is possible for the patient to still reach his or her growth potential. Malnutrition increases the risk of fractures and deformities during modeling.

The population most at risk for anorexia is also the group that experiences the highest rate of bone growth and development, namely, adolescents 13 to 18 years of age. This correlation has drastic consequences for bone health, not only while the individual struggles with anorexia, but also throughout his or her life. Although bone mass is expected to be lower than adult norms while growth is still occurring, anorexia in adolescents is closely tied to BMD below expected values for individuals of the same sex at comparable developmental stages, with decreased rates of bone accrual. Patients could have up to a 0.3% decrease in bone density per year, as opposed to the approximate 3% to 4% increase experienced by healthy individuals of the same age. Up to 50% of adolescent girls and 70% of adolescent boys with anorexia are found to have an age-adjusted Z-score of less than –1 for at least one measured site. Approximately 11% of adolescent girls have a Z-score of less than –2. Because of the typical mass increase seen in healthy peers, the gap between bone density of teens with anorexia and those without anorexia continually increases throughout the duration of the illness.

In addition to adverse effects on overall bone density, the very structure and physiology of bone is altered. Patients with anorexia experience higher levels of preadipocyte factor-1, an epidermal growth factor-like protein involved in regulating the differentiation of mesenchymal stem cells into either osteoblasts or adipocytes. These higher levels result in higher marrow fat content as opposed to bone tissue. Further changes in cell differentiation yield higher fatty yellow marrow content and lower red marrow. Tests for bone formation and bone resorption markers show declines for both, decreasing bone turnover rate. Slower turnover results in increased fracture risk, independent of bone density.

Additional changes occur in bone structure at the microscopic level. Compared with healthy bone, trabecular volume and trabecular thickness are lower, whereas trabecular separation is higher, even when no variation is identified in BMD. These changes also increase fracture risk. Improvements in weight and overall health can repair a great deal of damage due to anorexia; however, the lost opportunity for bone growth during this period cannot be recovered fully. Patients might never reach their potential peak BMD and maintain lower bone density throughout life. Women who struggled with anorexia during adolescence exhibit lower BMD in adulthood than do women who had anorexia for the same length of time with onset in adulthood.

With onset in adulthood, an individual already has attained peak bone mass; however, risks to bone health persist because maintenance is an ongoing process. When bones would otherwise be preserved at peak BMD, patients with anorexia exhibit changes similar to bone loss following menopause. The inner bone appears similar to postmenopausal patients, with changes in structure, decreased trabecular thickness and increased spacing, and a decreased number of trabeculae per area. Overall bone density and cortical thickness also are lower than in comparable healthy patients, although not quite as low as expected after menopause. Bone formation markers decrease but, unlike in adolescence, turnover as a whole is not slowed; bone resorption markers increase, compounding the rate of bone loss. In adult anorexic patients, 92% have osteopenia, and approximately 40% have osteoporosis. A related increase in fracture risk is assured with changes in both bone density and physiology. Even if patients recover from anorexia, it can be difficult to recover the lost bone mass, and they likely are left at a deficit that will, at best, not worsen.

If anorexia occurs or persists into advanced age, or past menopause for women, bone loss is further complicated by age-related changes. Even healthy women older than age 50 and healthy men older than age 70 are expected to demonstrate thinning of cortical bone, decreased overall density, and need for targeted exercise and supplementation to protect bone health. An eating disorder speeds up these degenerative processes and
clots are still a concern; however, risk of certain types of breast cancer actually are reduced.25

Other treatments target either bone production or bone resorption. Teriparatide (Forteo) acts similarly to parathyroid hormone to stimulate new bone growth in patients with severe osteoporosis (see Figure 5). A secondary medication is required to maintain the new bone. Teriparatide is administered by daily subcutaneous injections.25,26 Denosumab (Prolia) inhibits osteoclasts to reduce bone resorption. It is given only twice per year, also as a subcutaneous injection. Bisphosphonates, which also inhibit osteoclasts, are the most commonly prescribed group of medications for treating age-related osteoporosis. Common examples include alendronate (Fosamax), risedronate (Actonel), ibandronate (Boniva), and zoledronic acid (Reclast). These can be taken orally on a weekly or monthly basis, or intravenously on a yearly or quarterly schedule.25

Oral alendronate and risedronate are associated with compliance issues, even though pills are not required on a daily basis and improvements are expected in density and fracture risk. Absorption is poor, and these medications might bind to food, requiring the patient to take them with water before eating; afterward, the patient must remain upright for 30 minutes to minimize the risk of esophagitis.26

Options seem numerous, yet for patients with anorexia, standard treatments for improving bone density or impeding bone loss can be ineffective or less effective than for otherwise healthy patients. In addition, treatments not typically used for osteoporosis might be necessary to address underlying causes. Multiple therapies can be used concurrently to treat multiple factors influencing bone loss. Supplemental calcium and vitamin D are provided to address nutritional deficits because both are necessary for bone health; however, simply meeting the required intake of these nutrients has not been shown to increase BMD in patients with anorexia. Supplementation, as part of overall nutritional improvement, can promote healthy weight gain, which is directly correlated with improvements in bone formation. Yet, levels remain below those of healthy individuals. Correcting the weight and nutritional elements of anorexia is vital but only part of the solution for bone health. Because of the domino

Treatment Options

Standard treatments for decreased bone density stem from the particular causes most commonly being addressed. For patients with a mild decrease in bone density or small increase in fracture risk, treatment might focus on lifestyle choices to minimize behaviors, such as smoking and alcohol consumption, that have a negative effect on bone health. For patients with calcium or vitamin D deficiencies, supplementation might be sufficient to restore normal bone production or maintenance.19 These often are the simplest first steps to minimize bone loss in elderly patients or in those who are otherwise inclined to weakened bones. Increased exercise, especially weight-bearing exercise because of its beneficial effects on bone strength and density, might be recommended to help improve bone density or minimize loss.

A large proportion of patients with osteoporosis receive their diagnosis after a decline in hormones, either estrogen after menopause for women or testosterone around a similar age for men.19 For this reason, hormone replacement therapy with estrogen or testosterone, as appropriate, has been employed to improve bone density and other symptoms in many patients. This is no longer considered the standard of care, however.26 Estrogen is associated with some significant adverse effects, including increased risk of blood clots, heart disease, endometrial cancer, and breast cancer; therefore, estrogen generally is reserved for patients who are experiencing other menopause-related symptoms that will benefit from hormone replacement. Additional prescription interventions are available that provide the bone-protecting effects seen in estrogen with fewer adverse effects. The mechanisms of action for these drugs vary, and clinicians must consider carefully the best option for each patient.25,26

Hormone-related therapy such as raloxifene (Evista), a selective estrogen receptor modulator, has proven helpful for some women. Raloxifene provides benefits to bone density comparable to those of estrogen, while acting as an estrogen antagonist in other areas, thus avoiding some of the potential adverse effects.26 Blood
insulin-like growth factor-1 produced improved BMD in adolescents, and replacement paired with estrogen improved BMD in adults. For some adult anorexic patients who have been unresponsive to other therapies, deep brain stimulation has been successful in helping patients reach a higher body mass index than achieved previously in treatment, while also improving other symptoms associated with anorexia.

Unlike age-related bone density loss, which can be managed with lifestyle changes and nutrition or a single pharmacologic treatment, deficits due to anorexia require a multifaceted approach. No single treatment plan has been deemed ideal standard treatment for all bone loss due to anorexia, and further research is needed to determine the specific effect of many therapies on anorexic patients. Success requires treatment targeted at the various agents affecting bone development, as well as comprehensive treatment for the underlying eating disorder and psychological motivators. A team of professionals that includes the patient’s primary care physician, psychiatrist, and dietician usually collaborate to provide an extensive care plan on an outpatient or inpatient basis that fits the patient’s needs. Even in overcoming anorexia and receiving optimum treatment for symptoms, patients do not catch up to healthy peers and are likely to continue life with somewhat diminished skeletal integrity. All treatment options require ongoing monitoring of bone density and follow-up throughout life.

Exercise, which is expected to improve general bone strength and density, is associated with a decrease in bone density in patients still struggling with anorexia, although it remains beneficial for patients who have recovered in regaining some of the density lost during illness. In adult patients who have increased bone resorption markers, bisphosphonates effectively aid in increasing BMD. In adolescents, however, who have decreased markers for both resorption and production, bisphosphonates are ineffective in improving bone density. Teriparatide is effective in increasing bone density; however, it is reserved for patients with a high risk of fracture. Some, but not all, hormone replacements can be beneficial if given at the appropriate stage of life. Oral estrogen–progesterone birth control pills, for instance, might help a patient resume menstruation but are not effective in increasing BMD. A small oral dose of estrogen given to girls with immature bone age or a transdermal patch administered to adolescents with mature bone age have produced improvements in bone density. A transdermal patch of testosterone administered to adult women failed to improve BMD, although testosterone patches did improve bone formation marker levels. Treatment with dehydroepiandrosterone, a steroid used to make androgens and estrogens, has proven to improve patient weight and mood, but it does not improve BMD. Short-term use of replacement Figure 5. Radiographic images of lumbar vertebrae from normal (A) and osteoporotic (B) patients. Open access image reprinted with permission from Dougherty G. Image analysis in medical imaging: recent advances in selected examples. Biomed Imaging Interv J. 2010;6(3):e32. doi:10.2349/biij.6.3.e32.
The expected precision of the scan also influences the timing of follow-up scans. Better precision produces less fluctuation in measurements, indicating true biologic change and providing greater confidence that the change indicated has truly taken place. With poor precision, the interval between scans is longer to allow for greater change and avoid unreliable results. Precision is affected by equipment variations and sites selected, as well as by the staff performing examinations. The greater the variability in positioning and analysis, the poorer the precision. For many adult patients, follow-up examinations require a wait of 1 to 2 years or more for reliability, depending on the therapy being monitored. Pediatric patients might have sufficient changes to allow follow-up scanning in 6 to 12 months. Whatever the age of the patient, it is crucial to use the appropriate software and reference databases for each examination. A standard adult bone density report provides the following information:

- The bone density at the measured sites.
- A Z-score comparing the patient’s results to individuals of the same age, sex, and ethnicity.
- A T-score comparing the patient’s measurements to the average peak bone density for a healthy young adult.
- A fracture risk assessment.

The T- and Z-scores are given as standard deviations from a norm, indicating a relative greater or lesser risk of fracture. The fracture risk assessment is expressed as a percentage and represents the predicted risk of fractures within a specified time frame.

Because the bones of pediatric patients are still developing, it is inappropriate to compare these patients to adult norms. Bone densitometry software includes pediatric-specific databases that allow comparison of a particular patient with the demographic data for a healthy pediatric population. A pediatric bone density report does not include a T-score, but instead consists of data on bone size, density, and a Z-score adjusted for age, sex, and ethnicity. Failure to use an appropriate database for comparison can misrepresent bone density and the risk of fracture.

Understanding the normal development of the skeleton throughout the lifespan and how assorted disease processes present in densitometry can help the
technologist identify a potential problem before the examination is even completed, recognizing potential pathology as opposed to software or equipment malfunction. Changes might be required in study protocol, or additional information might need to be collected. Recognizing scoliosis in the posteroanterior lumbar spine, for instance, might require selecting the proximal hip on the side of convexity, as opposed to an otherwise arbitrary selection of right or left hip. Inaccurate bone mapping could reveal that the correct software was not properly used to detect edges in low-density bone. For some equipment, the technologist must make that selection; others optimize settings based on height and weight data, which should be verified for accuracy.

The technologist should ensure the correct reference database is used for age, sex, and ethnicity. In pediatric populations, technologists also might need to obtain and document information on bone age and sexual maturation because that information provides more accurate references for healthy growth and might

not correlate with chronological age. This information can aid the physician in more accurately determining whether intervention is necessary. In addition, when low bone density is found in pediatric patients, it is important to provide information on the size and shape of bones along with the density. A reportedly low BMD could be the result of abnormally low density, or it might reflect bones that are narrow or short for the patient’s age; knowing which is the likely cause is valuable to the pediatrician.7

It might be necessary for the technologist to ask additional questions to help reveal the underlying cause of an abnormal presentation. Questions might cover conditions not listed on an initial questionnaire, possible past abuses (eg, physical trauma or lack of nutrition or medical care), as well as possible anomalies in development. Technologists should obtain as thorough and accurate a history as possible without bias toward one condition. Although slowed growth in an adolescent could indicate a potential eating disorder, it also could be associated with various endocrine and gastrointestinal disorders, along with other strictly physiologic causes (see Table).10 An imprudent technologist can cause undue stress to the patient or impede an accurate diagnosis through misdirection.

**Patient Care**

Just as much as technical competence is required to decide how best to execute the examination, effective patient care is required to ensure the examination is carried out successfully and with the most benefit to the patient. Even in the more typical bone densitometry patient, osteoporosis and bone loss can have numerous underlying causes or can even result from the combined effects of multiple agents.24 The caring technologist acknowledges the person as a whole and the complexity of bone health, without finding or implying fault on the part of the individual as to the cause of bone loss.

Various aspects of the patient’s health and life are considered when establishing the best treatment plan. Multiple factors—from diet and exercise to medication and supplementation—are considered, and a combined approach might be implemented to meet individual needs.14 Patients with eating disorders are treated in the same manner as other patients with bone loss, with the important addition of mental health care. Patients who have anorexia nervosa are dealing with multiple physical symptoms at once, while waging an internal war to

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### Table

**Differential Diagnoses for Unintentional Weight Loss**10,32,33

<table>
<thead>
<tr>
<th>Area</th>
<th>Disorder/Condition</th>
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<tr>
<td>Endocrine</td>
<td>Hyperthyroidism, hypothyroidism</td>
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<td>Hyperparathyroidism</td>
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<td>Diabetes mellitus</td>
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<td>Adrenal insufficiency (Addison disease)</td>
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<td>Rheumatic</td>
<td>Rheumatoid arthritis, juvenile rheumatoid arthritis</td>
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<td>Lupus</td>
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<td>Gastrointestinal</td>
<td>Celiac disease</td>
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<td>Ulcerative colitis</td>
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<td>Crohn disease</td>
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<td>Parasites</td>
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<td>Superior mesenteric artery syndrome</td>
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<td>Neurologic</td>
<td>Stroke</td>
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<td>Parkinson disease</td>
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<td>Dementia</td>
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<td>Depression</td>
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<td>Stress, anxiety</td>
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<td>Obsessive-compulsive disorder</td>
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<td>Immune system</td>
<td>HIV, AIDS</td>
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<td></td>
<td>Hepatitis C</td>
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<td></td>
<td>Tuberculosis</td>
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<tr>
<td>Pharmaceutical</td>
<td>Over-the-counter medications, herbal remedies</td>
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<td></td>
<td>Prescription drugs</td>
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<td>(eg, anticonvulsants, antidepressants, thyroid medication)</td>
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<tr>
<td></td>
<td>Prescription drug cessation</td>
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<td>(eg, antipsychotics)</td>
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<td></td>
<td>Substance abuse</td>
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<td>Other</td>
<td>Chronic obstructive pulmonary disease</td>
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<td></td>
<td>Congestive heart failure</td>
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<td>End-stage renal disease</td>
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<td>Malignancy</td>
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<td>Excessive exercise</td>
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regain control of their own bodies. Health care professionals, no matter how brief their interactions with these patients, can either bolster the patient’s desire to conquer this disorder or add to the existing obstacles.

Whether performing a scan to diagnose a possible eating disorder, to monitor disease progression, or to evaluate the effectiveness of a therapeutic intervention, the bone densitometry technologist must use tact and empathy during the patient interview and throughout the examination. Although clinical history questions might seem routine for most patients, in the case of patients with anorexia, they can provide meaningful details and help guide appropriate treatment. The technologist should collect as much information as possible about the patient’s diet, any dietary supplements, exercise habits, and a female patient’s menstrual history. An accurate report about symptom duration and the time since initiating treatment, if applicable, provides the context for assessing the severity of bone damage and the efficacy of therapy. Unlike a primary care physician or other health care professional who sees the patient frequently, the technologist does not have the opportunity to build the same rapport over time, and these questions can be especially delicate if a diagnosis has not been made or treatment has not been initiated. In addition, the patient might be struggling with feelings of guilt or denial.

Care also should be taken in providing education to the patient recovering from or suspected of having an eating disorder. Standard advice given to osteoporosis patients regarding diet and treatment options can be inaccurate for patients whose bone loss is due to anorexia. The technologist must be aware of how treatment options change when dealing with patients at various stages of development and with various comorbid conditions to avoid misguiding the patient or promoting unrealistic expectations of treatment.

All patients require an empathetic approach and a focused effort adapted to their unique situations, but patients striving to recover from eating disorders present a particular challenge in this regard. Health care professionals can become accustomed to straightforward medical conditions and diagnoses with known causes, easily recognizable presentations, predictable progressions, and standard treatment options. These types of conditions are more readily understood, often include familiar elements that health care providers have personally experienced to some degree, and are therefore more relatable. The etiology of eating disorders, however, is still not fully understood, and reliable treatment plans have not been established. The very nature of eating disorders involves development of behaviors that contradict social norms (eg, taking pleasure in food, building social experiences around eating and drinking) and even basic human instincts for survival (eg, consuming sufficient nutrients to protect the body, ensure organ function, and support the normal stages of growth). Not only are behaviors often baffling to health care personnel, but the attitude of patients toward the behaviors, such as the belief that there is nothing unusual or harmful in their actions, can be nearly incomprehensible.

It can be challenging for a health care professional to avoid displaying negative emotions in this situation. He or she might disapprove of the patient’s behavior or even feel averse to providing care. These feelings can be difficult to mask and could give the impression that the patient is at fault, responsible for bad outcomes because of poor decisions, or unworthy of receiving care. Even a professional who genuinely desires to help might exhibit frustration toward the patient because of an inability to connect, feeling helpless to make a difference, or lack of patient cooperation during care. The technologist need not have personal experience with eating disorders, however, to express genuine concern for patients’ well-being or a desire to help them receive the best care possible without judgment or blame.

Technologists must avoid dismissing or belittling a patient’s thoughts or feelings, even if they are not readily understood. Instead, the technologist should acknowledge the patient’s feelings and respond positively or redirect the conversation to something that the patient appropriately views as positive. Understanding the extent of anorexia’s effects on both body and mind and the potentially confounding attitudes the patient might have will help eliminate negativity stemming from misconceptions or frustrations. Even if caring gestures do not receive an overt positive response, they contribute to the supportive environment necessary for the patient’s long-term recovery.
Conclusion
Understanding the normal physiology of bone and how anorexia nervosa affects a patient at different stages of development will equip technologists to provide better care. Anorexia is a complex condition requiring coordinated treatment from multiple health care professionals to address the underlying psychological causes of the disease, as well as the various physical complications and symptoms. Anorexia affects patients of different ages and both sexes, but the highest rate of incidence occurs among adolescent girls at a crucial point in skeletal development. Changes due to anorexia greatly increase the risk of osteoporosis and fractures before recovery, with lingering effects on bone health throughout life, even after effective treatment. Technologists should understand how bone density fits into the broad spectrum of anorexia complications and how they can contribute to quality care.

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

1. After 50 years of age for women and 70 years for men, the daily calcium allowance:
   a. decreases gradually for the remainder of the lifespan.
   b. decreases to slightly below young adult levels.
   c. increases to 1200 mg per day.
   d. exceeds the recommended allowance for people aged 9 to 18 years.

2. Insufficient vitamin D can result in _______ in children or _______ in adults.
   a. rickets; osteomalacia
   b. scurvy; swollen joints
   c. thin bones; xerophthalmia
   d. stunted growth; tetany

3. An eating disorder occurs when an individual fails to maintain healthy nutrition as a result of:
   a. lack of access to nutrients.
   b. deliberate starvation.
   c. physical causes.
   d. psychological causes.

4. What is the key differentiation between anorexia nervosa and other eating disorders?
   a. alternating bingeing and purging
   b. extreme loss of weight
   c. no attempt to minimize caloric intake
   d. normal or overweight appearance

5. Symptoms of hormonal changes associated with anorexia can include all of the following except:
   a. sensitivity to cold.
   b. increased heart rate.
   c. increased cholesterol level.
   d. decreased fasting glucose level.

6. In long bones, the primary ossification center is located in the:
   a. epiphyseal plate.
   b. medullary cavity.
   c. epiphysis.
   d. diaphysis.
Directed Reading Quiz

7. Parathyroid hormone stimulates the number and activity of:
   a. osteoblasts to break down bone.
   b. osteoblasts to build new bone.
   c. osteoclasts to break down bone.
   d. osteoclasts to build new bone.

8. When an individual has ceased growing, remodeling occurs ______ to maintain the structural integrity of bones.
   a. approximately once a year
   b. only after an injury
   c. constantly
   d. after osteoporosis develops

9. Which of the following are considered risk factors for secondary osteoporosis?
   1. long-term heparin use
   2. emphysema
   3. history of alcoholism
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

10. Anorexia affects bone structure at the microscopic level, resulting in lower trabecular:
   1. volume.
   2. separation.
   3. thickness.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

11. Most adult patients with anorexia (92%) have:
   a. osteoporosis.
   b. osteopenia.
   c. a history of stress fractures.
   d. a Z-score less than –2.

12. Which hormone-related therapy for bone loss provides benefits for bone density comparable with that of estrogen, while acting as an estrogen antagonist in other areas?
   a. raloxifene (Evista)
   b. teriparatide (Forteo)
   c. denosumab (Prolia)
   d. risedronate (Actonel)

13. Simply meeting the required intake of calcium and vitamin D has not been shown to increase ______ in patients with anorexia.
   a. body mass index
   b. self-esteem
   c. bone mineral density
   d. heart disease

14. ______ is the primary clinical tool for measuring bone density and the only method appropriate for official diagnosis of osteoporosis and osteopenia.
   a. Computed tomography
   b. Quantitative sonography
   c. Positron emission tomography
   d. Dual-energy x-ray absorptiometry (DXA)

15. In DXA, precision is affected by equipment variations, sites selected, and the staff performing examinations.
   a. true
   b. false

16. A pediatric bone density report includes all of the following except:
   a. bone size.
   b. density.
   c. T-score.
   d. Z-score.
Directed Reading Evaluation

Anorexia Nervosa and Bone Densitometry

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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Anorexia Nervosa and Bone Densitometry

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Improving Care Across the Globe

Going Paperless in China

In the fall of 2016, Veleda Stephens, MBA, R.T.(T), and I worked as ASRT Foundation Community Outreach Fellows at the General Hospital of Ningxia Medical University in Yinchuan, China, to help find ways for the staff to better serve the many patients they see every day.

The hospital is a comprehensive tertiary facility integrating clinical treatment, education, scientific research, examination, and training in Ningxia. The staff provides medical services for Yinchuan, which is the capital of the Ningxia Hui Autonomous Region and home to nearly 2 million people, as well as the people in the nearby areas of Inner Mongolia, Shanxi province, and Gansu province.

The sheer number of patients the radiation therapists see make patient interactions brief, and because there are only 2 linear accelerators, the therapists have to work quickly to treat every patient scheduled that day.

Working alongside our Yinchuan colleagues, we found ways to streamline the hospital’s processes to allow therapists to provide more patient-centered care. One of the things we accomplished was to help them realize that they could enhance their workflows and become more efficient when treating patients by going paperless.

Although the hospital has excellent documentation processes, everything is documented manually in logs and manuals, which is time consuming. Implementing a more paperless process will help shorten the amount of time doing paperwork, giving the therapists more time with their patients and elevating patient privacy and confidentiality.

Elevating Patient Care in Cape Verde

I had the opportunity to work as an ASRT Foundation Community Outreach Fellow in Cape Verde (an island country 350 miles off the coast of West Africa) as part of a RAD-AID International outreach team. The team’s goals were to provide sonography services and implement PACS in Sao Felipe, the capital of Fogo Island, and provide sonography services in Mosteiros, a small agricultural town. Both hospitals were clean and well organized but lacked the resources taken for granted in the United States.

The first few days in Sao Felipe were stressful. The team had planned to work around the clock to ensure we imparted as much knowledge as possible and implemented the PACS quickly, but we had not taken into consideration the culture of Cape Verde. The cultural and language differences between the United States
Empowering Sustainable Change in Malawi

Over the course of 2 weeks, ASRT Foundation Community Outreach Fellows Thomas Wall, RDMS, RVT; Rick Morris, a retired R.T.; and I worked with radiologic technologists at Kamuzu Central Hospital and 15 third-year radiography students at the Malawi College of Health Sciences to implement sustainable changes that will improve patient care in Lilongwe, Malawi.

Although radiography is the primary modality in Malawi, the technologists also are expected to perform sonography in the hospital. There is no formal sonography training program, so the primary focus of the trip was on the students and on making sonography a sustainable avenue for them.

We created a beginning ultrasound curriculum for the college to implement and provided lots of hands-on training at the hospital and in the classroom using 2 laptop ultrasound machines that Wall brought. The hands-on training we did was supplemented by classroom lectures and slideshow presentations, which were left for the college to use as a resource.

This work provided a great start to developing a sustainable sonography program at the Malawi College of Health Sciences, but as Wall noted during the trip, more follow-up education is needed to keep the program moving forward. We laid the groundwork for this program, but future outreach efforts will be needed to move it forward. We got the students curious about learning sonography, and now we need to help them continue to educate themselves.

During our trip, Morris emphasized that each step forward with the new program needs to be taken carefully to ensure that what is implemented can be sustained and that it will continue to teach people for years to come.

The secondary focus of the trip was improving the quality of ultrasounds being performed at Kamuzu Central Hospital. As a team, we worked at the hospital every morning, scanning up to 15 patients each, teaching best practices to the students and technologists.

Patients arrived for their examinations promptly at 8:00 every morning. They waited for hours at a time, sitting on old, hard, wooden benches, or simply...
standing in line. I admired how these patients showed up for the examinations. The entire time we were there, I never heard a patient complain about the wait. They were excited to have a scheduled appointment and dedicated patient care. It was truly amazing.

The region is extremely poverty stricken, which means that the people who live there cannot afford routine medical care. They come in only when their illness or injury renders them unable to work or to continue their daily lives.

While 2 weeks was not long enough to elevate patient care in Malawi to what it is here in the United States, we know we had a great impact on the technologists and students we worked with. Before we left, several of them were asking questions about how to perform examinations differently while tailoring it to the patient's anatomy. The technologists and students we worked with still contact us with questions, and we are thrilled to be able to continue to be a resource for them.

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Jason Lee, BS, R.R.A., R.T.(R)(CT), is a registered radiologist assistant and works as a radiologic technologist for Missouri State University Care Clinic in Springfield. His duties include performing examinations, lab work, and dispensing medication for uninsured patients.

Rick Morris is a retired radiographer with more than 35 years of experience in radiography and computed tomography. He lives in Muncie, Indiana, with his lovely wife, Kelly.

Working to Save Children in Laos

A lack of access to quality patient care for children in Laos leads many families not to seek medical care until their sick or injured child is in such poor condition it might be too late for treatment. This is largely because there are only 2 pediatric hospitals in the country, and medical professionals at the provincial hospitals are not trained or equipped to handle surgeries or extensive care for young children and infants.

Families have to travel great distances by foot, bicycle, or motor bike to have their children treated at 1 of the facilities. Although children 15 years and younger receive free medical care at Laos Friends Hospital for Children, it is a huge financial burden for these families not to work while tending to their young one.

They often wait several days or weeks before coming to the hospital, sometimes waiting several hours just to be seen once they arrive. The financial loss and the hardship of seeking medical care are 2 reasons children who arrive at the hospital often have advanced illness or severe injuries. If there were more facilities and more trained radiologic technologists, more children could be treated throughout the country.

Increasing the number of trained technologists is what sent me to work at Laos Friends Hospital for Children in Luang Prabang, Laos. As a Watson ASRT Foundation Community Outreach Fellow in partnership with RAD-AID International, I worked to advance sonography practices there. The Foundation and RAD-AID are committed to helping educate and train medical imaging professionals at this hospital as there is little to no imaging education in the country.

Drawing on my experience as an educator in the United States, I worked with RAD-AID to develop a curriculum for training radiologic technologists in Laos on how to safely use sonography in their treatments. When I arrived in Luang Prabang, I set to work training a technologist who had completed radiography training and was beginning to perform sonography, only stepping in when something was not being understood. I wanted to ensure the he would be a good resource for other radiologic technologists who would be learning sonography. It was a beneficial endeavor as it increased his...
confidence in sharing his knowledge with others and also allowed me to fill in a few knowledge gaps for him along the way.

The knowledge and skills I helped teach and hone will be present in Laos for years to come and will continue to affect the area positively. This information will continue to spread through the health care system there and will increase the availability of these procedures for generations. It will give hundreds, even thousands, of people a future they would not have had if they were not able to obtain treatment for their illnesses and injuries.

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To learn more about global outreach opportunities, visit foundation.asrt.org.
Implantable Infusion Pumps in the MR Environment: Safety Concerns

In January 2017, the U.S. Food and Drug Administration (FDA) communicated that they have received reports of serious adverse events associated with the use of implantable infusion pumps in the magnetic resonance (MR) environment. Adverse events included patient injury and death as a result of medication dosing inaccuracies and other mechanical problems with the pump.

The FDA stressed that only implantable infusion pumps labeled as MR Conditional can be used safely within an MR environment, and only under specified conditions of safe use: the make and model of the pump determines these conditions. To help reduce the likelihood of serious adverse events, the FDA put forth recommendations for patients and MR technologists to follow before, during, and after an MR examination for a patient with an implantable infusion pump (see Boxes 1 and 2).

Box 1

Recommendations for Patients With Implantable Infusion Pumps Needing MR Examinations

Make sure the MR technician knows you have an implantable infusion pump.
Know the make and model of your implantable infusion pump.
You might need to have your infusion pump checked or reprogrammed after an MR examination, even if your pump is labeled as MR Conditional.
Only implantable infusion pumps labeled as MR Conditional can be scanned safely, and only under the specified conditions of safe use.
The before, during, and after instructions following an MR examination differ depending on the make and model of the implantable infusion pump.

Box 2

MR Technologist Recommendations for Scanning Patients With Implantable Infusion Pumps

Follow all institutional patient-screening policies.
Do not scan a patient if you do not have the pump’s instructions for safe MR exposure.
Only implantable infusion pumps labeled as MR Conditional can be scanned safely, and only under the specified conditions of safe use.
The before, during, and after instructions following an MR examination differ depending on the make and model of the implantable infusion pump.
Ensure that the implantable pump model can be safely imaged on the MR system at your site.

To read the full FDA safety communication visit asrt.org/as.rt?dQLrTZ.

The lives, careers, and challenges of female scientists have not been well-recorded in the history books. The Madame Curie Complex: The Hidden History of Women in Science attempts to remedy that, describing the accomplishments of some of history’s top female scientists as well as little-known facts about them. Equally important is the book’s attempt to address gender bias and underrepresentation of women within the science profession.

In a chronological narrative arranged by era, the author details some of the many women who dedicated their lives to various scientific fields and pursuits but whose contributions were left out of the historic records. The first section includes individuals such as Marie Curie, Lillian Gilbreth, and the “Women of the Harvard Observatory.” Another section, “Cult of Masculinity in the Age of Heroic Science,” includes information about Rosalind Franklin, who was part of the team that discovered the double helix structure of DNA, and other women who were involved in the Manhattan Project. The contributions of scientists such as Barbara McClintock, Evelyn Fox Keller, Jane Goodall, and Dian Fossey are featured in the section called “American Women and Science in Transition.”

As the book progresses through time and discipline, it touches on topics outside the work realm that affected the women’s lives, such as love, motherhood, family, fame, and obscurity, and shaped who they were. Each biography builds on the previous one, allowing the reader to compare and contrast them and to recognize patterns. They also provide a lessons-learned aspect about the importance of gender equality in science, suggesting that future generations should work to ensure that the achievements of talented women in scientific and engineering professions are recognized and not overlooked or underappreciated.

The Madame Curie Complex is a well-organized book about some of the most prevalent women in science and the inequality they suffered as they pursued the world’s most important scientific discoveries. Despite the book’s text-heavy structure, its organization makes it an easy read, and the photographs, though few, provide a welcome glimpse into the lives of the scientists. Overall, it is an interesting book for any reader who wishes to learn about history’s life-changing work and discoveries from the perspective of those not often noted in history books.

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imaging findings, along with pearls of wisdom gained from years of relevant experience. Finally, the book includes a discussion of disease spectrum and differential diagnoses along with instructional radiology images. Further reading references are listed at the end of each case. The medical terminology used is precise to illustrate differential diagnoses and the full spectrum of the diagnosis. Although the terms are beyond what is required for a radiologic technologist, they are presented alongside images for clarification.

Radiologic technologists, particularly those employed in computed tomography and magnetic resonance imaging, can benefit from this book by viewing the images and learning and reviewing the proper medical terms for clinical histories, which will widen and deepen the scope of their knowledge within diagnoses.

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The purpose of the Emergency Radiology COFFEE Case Book is to aid in the development of the essential competency of reliable, timely, and accurate interpretation of radiology images necessary for the clinical practice of emergency radiology. The acronym COFFEE, which stands for Case-Oriented Fast Focused Effective Education, was first used in the early 2000s in emergency radiology continuing medical education courses and has proved to be a quick and effective learning method. This book is a go-to reference for radiologists and clinicians in emergency medicine and trauma surgery to develop, throughout their clinical duties, their confidence and performance as it relates to imaging.

The book’s organization is by clinical presentation so as to demonstrate actual clinical radiology practices within an emergency department setting. The cases presented in the book are divided into 2 main parts: nontraumatic conditions and traumatic conditions. Part 1, nontraumatic conditions, is further divided into 5 anatomic sections: abdomen, thorax, otolaryngology, neurology, and musculoskeletal. Part 2, traumatic conditions, includes neurology, thorax, abdomen, and musculoskeletal areas.

Each chapter presents a case with relevant clinical history, presentation symptoms, and 1 to 3 diagnostic images. This format continues with a diagnosis determined from those images, highlighted with colored arrows on image close-ups, and a discussion of the disease, appropriate imaging modality, relevant medical knowledge, and examination of the preferred imaging modalities. A clinical synopsis briefly describes the patient’s treatment.

A self-assessment section is provided for additional learning about the importance of specific clinical and


Each chapter in this introductory sonography textbook includes objectives students should meet, vocabulary with definitions, critical thinking exercises, and review questions. The “sound off” sections are intended to encourage students to be more involved with peers, the profession, and academic concepts that promote leadership, critical thinking, and lifelong learning. Multiple drawings and screenshots of actual sonograms help reinforce the content and software applications that likely are being covered in the sonography program. Extra resources are available to students and instructors via Wolters Kluwer’s website, The Point, such as slideshow presentations, videos, laboratory exercises, and case notes; additional resources for instructors include a test generator and lesson plans.


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Bookshelf

Historical Significance

The textbook is separated into 2 sections; the first is an introduction to sonography and the second covers patient care. The content is basic information that any sonography student should be learning. However, the focus on student success strategies, time management, leadership, peer support and learning, and self-reflection is more in-depth than seen in other introductory medical imaging books. Section 2 also includes a helpful table on cultural competence and communication styles, which the beginning sonographer will benefit from reading.

Other topics include medical terminology, translation resources for English-to-Spanish phrases, patient care procedure details, common lab tests, and electrocardiogram dysrhythmias. Essentials of professionalism in the clinic are stressed, and strategies to survive the first clinical experience are shared, including common stressors, modeling professionalism, work ethic, and self-reflection. Questions, case studies, and critical thinking sections encourage the growth of the student as a professional. The section on differentiation of touch into 2 types used during patient interactions—a concept not often explained well in other texts—is explained in a way that will help new students understand the reasoning behind each type.

The book touches on Myers-Briggs typing as a way for students to discover their personality types, strengths, weaknesses, and learning and communication traits based on the idea that this knowledge will help them to better understand how to help others. In addition, best practices of sonography, including proper posture and positioning to decrease work injury, are covered in depth.

The last chapter covers basic sonography examinations, guidelines, and quality assurance standards. The explanations help students to understand their role and how it affects image quality. Also included is a basic overview of required elements for scanning and how variations and adaptations occur because of patient condition and performing examinations in the mobile environment.

*Introduction to Sonography and Patient Care* is a comprehensive, well-written book that covers basic information needed by student sonographers and includes topics not included by similar textbooks. Each chapter flows into the next logically, making it easy to read and to locate information quickly. It is a good reference for its intended audience: the student sonographer. Medical imaging program educators might find this a good resource for the ethics, career exploration, leadership, student success, and communication sections. Practicing sonographers might find it a useful quick reference for keeping their skills current.

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Tracking to Excellence: Automating Breast Imaging Wait-time Monitoring

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Providing patients with a low-anxiety and quick experience is an important aspect of quality health care. For the past decade, a screening mammogram has been recommended for most women older than 40 years. Although mammogram examinations take minimal time to finish, many hospitals do not return results for patients or schedule additional diagnostic mammograms quickly. Most institutions take approximately 1 week to deliver mammogram results to the patient; wait times can be longer for patients with abnormal results. Legally, the Mammography Quality Standards Act (MQSA) allows up to 30 days after an examination for delivery of mammographic findings (in layman’s language) and follow-up recommendations. Many patients report this waiting period as the most stressful part of their procedure.

Some patients prefer a rapid results workflow that reduces wait time, allows patients to receive results promptly, and offers immediate completion of further diagnostic imaging. Some authors have proposed allowing patients to buy a rapid result, hand-delivered by a physician. However, the cost of accommodating rapid results, including overhead incurred by the imaging facility, could outpace what patients would be willing to pay for the option.

Balancing patient preferences with the effect rapid result workflows might have on a facility represents a clear struggle in the competitive space of screening mammography. Despite conflicts with operational efficiency, a patient-centered online model, with mammogram readings done in real time, is essential to a patient satisfaction-focused approach in a mammography clinic.

Workflow

The breast-imaging department at the Mayo Clinic in Arizona adopted a real-time reading workflow in which patients are invited to wait (< 30 minutes) to receive their results in person. This practice, called the rapid-read program, began in 2014 and has evolved to accommodate changes to staff, facilities, and technology. One of the Mayo Clinic’s founding values—the needs of the patient come first—creates an administrative environment where costs of such a program are tolerated willingly. It also is thought that this type of program allows for a superior mammography experience and acts as an advertisement to attract and retain patients.

The Original Clipboard Approach

The original Mayo Clinic workflow relied on pen and paper. Technologists offered patients the option of waiting for their results. For patients requesting this service, technologists informed the physician that the patient would wait and marked the time and the name of the patient on a clipboard in the technologists’ control area. The technologist periodically asked the physician to determine when they could dismiss the patient or whether additional imaging was needed.
The pen-and-paper process had noticeable deficiencies. First, auditing the workflow required significant rework to migrate the paper record to a Microsoft Excel spreadsheet. Because of the challenges associated with converting the data into a digital format and the variability in data accuracy, there was no record of average turnaround time, percentage of patients choosing to wait, and instances of failure to achieve a 30-minute wait time for the patient. This lack of long-term feedback prevented the department from optimizing its efficiency and maintaining the integrity of the rapid-read program. Second, the immediate feedback available to staff was isolated to the clipboard’s physical location, and start time notation did not communicate delayed cases with any particular urgency. Finally, the pen-and-paper process was relegated entirely to the technologists, requiring them to float in and out of the reading room between patients in an attempt to receive word from the radiologist when a patient could be dismissed or regarding the need for additional images.

The Monitoring Tool
To improve workflow deficiencies, the Mayo Clinic replaced the clipboard with an electronic tablet equipped with scheduling software. An Apple iPad with a FileMaker application (FileMaker Inc) replaced the clipboard and records the in-and-out times of rapid-read patients. Technologists can identify patients who opt to wait for results by pressing a button. When a patient is dismissed, the technologist marks them as such. Because in-and-out times can be recorded, this resolves the issue of converting data into a digital format and allows for analytics. In addition, the iPad application includes a timer for each patient. This informs staff of how long a patient waits and includes color-changing features to alert staff to delays. The data collected can be analyzed to determine average wait times and outliers. The addition of a second iPad slightly improved issues with physical restrictions of the process; however, the workflow remained technologist directed.

Team-based Workflow
In collaboration with physicians and scheduling staff, the technologists overhauled the communication and workflow surrounding the rapid-read program. The monitoring tool was expanded to support this new approach. With the new workflow, the monitoring application is available at every clinical computer workstation within the department, online, and via iPad. Technologists, radiologists, and scheduling staff all interact with the program to communicate a patient’s status seamlessly throughout the department. The Figure shows a screen shot of the application’s user interface.

At the beginning of a workday, all patients scheduled are imported automatically into the application. In addition to software-based monitoring, a printed schedule is provided for reference on a single sheet of legal-sized paper. When a mammogram examination concludes, technologists give the patient the option of receiving their results within 30 minutes. Patients who want this free service are instructed to return to the scheduling desk and request a pager. The technologist presses the Patient Waiting button, which moves
that patient from the Scheduled list to the Waiting list. Patients on the waiting list immediately are visible to the radiologists, who reprioritize their reading to address waiting patients as soon as possible.

Comparable to the device common in restaurants, the pager given to waiting patients allows them to wait outside the traditional waiting room. Most patients choose to wait in the coffee shop or the lobby, which has a piano for visitors to enjoy. The opportunity to wait in a larger, more welcoming space presumably helps reduce patient anxiety.

When the radiologist has finished reading the mammograms, patients who can be dismissed are moved to the Ready for Dismissal category. The scheduling staff receives notification that the patient may leave. Patients are paged and provided with their results—the same results they otherwise would receive up to 30 days later. If the patient needs further imaging, the technologists are alerted and a decision is made as to whether they can accommodate additional diagnostic procedures immediately. The technologists then call the scheduling staff, who page the patient. The scheduling staff informs the patient of their options: to return immediately to the imaging dressing rooms for additional imaging or to schedule an appointment for a later date.

By digitizing the workflow, the patient’s status can appear in many places at once. This balances the process. Technologists no longer act as go-betweens; they can focus on performing patient examinations. It also allows patients to receive their mammogram results within approximately 30 minutes and schedule further diagnostic examinations on the same day when needed.

Discussion

This workflow has improved patient, radiologist, and technologist satisfaction. Because mammography often is a stressful procedure, many women do not schedule recall appointments. About 20% of women with a history of breast cancer do not adhere to guidelines for follow-up mammography. Accordingly, the rapid-read program allows the hospital to follow up immediately, preventing patients from falling through the cracks.

Furthermore, this process has helped technologists in many ways. Despite technologists being trained to help worried patients, patient stress often is imparted on technologists. A quick turnaround time decreases patient worry thus improving the work environment for technologists. When patients are less stressed, technologists can take accurate mammograms with ease. In addition, technologists originally were responsible for mediating between radiologists and patients, but now radiologists also use the monitoring tool. Technologists no longer act as intermediaries and seem less anxious throughout their workday.

If used in other hospitals, this efficient workflow could help lower radiologist stress as well. Many radiologists do not want to read mammograms because mammography has the greatest legal liability. However, many claims of malpractice begin with delays in diagnosing breast cancer. So, quickly performing follow-up procedures could ease the physician’s burden.

Finally, this tool allows everyone to track the effectiveness of the rapid-read program. The digital application provides the team with real-time feedback on how long the patient has been waiting and long-term feedback on how efficient their service has been.

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Victor Pizzitola, MD, is a radiologist and the breast imaging division chair as well as an assistant professor of radiology for Arizona’s Mayo Clinic School of Medicine.

References

Management Toolbox

Tracking to Excellence: Automating Breast Imaging Wait-time Monitoring


Approximately 50% of magnetic resonance (MR) imaging studies worldwide are ordered with contrast. Gadolinium is the element of choice for contrast MR imaging, and evidence shows that multiple doses of gadolinium contrast cause gadolinium retention in certain regions of the brain. All gadolinium–based contrast agents used for MR studies are chelates of gadolinium because gadolinium on its own is highly toxic. When bound with a ligand molecule, the toxicity of these agents is reduced dramatically. Several types of gadolinium contrast agents have been approved by the U.S. Food and Drug Administration.

To understand gadolinium contrast deposition, it is important to know how gadolinium agents are structured. They can have a linear or a macrocyclic structure. Linear agents have an elongated organic molecular ligand that wraps around the ion. The linear agent’s structure is “open chain,” whereas in the macrocyclic structure, the gadolinium is “caged” in the ligand. Linear and macrocyclic agents can be either ionic or nonionic. Ionicity is closely related to osmolality (the number of dissolved particles per kilogram of water). Typically, ionic agents have a higher osmolality. An exception is gadobutrol (Gadavist), which is nonionic but has a high osmolality. With nonionic agents, the number of carboxyl groups is reduced to 3, which neutralizes the 3 positive charges of Gd³⁺. With ionic agents, the remaining carboxyl groups are salified with sodium or meglumine. The main difference between nonionic and ionic contrast media is that an ionic compound dissociates into charged particles when it enters a solution such as blood. Nonionic contrast media do not dissolve when they enter a solution, and they have a lower viscosity. Although ionic and nonionic gadolinium agents have higher osmolarity than blood, the osmolality of nonionic gadolinium agents is closer to blood; therefore, extravasation of a nonionic gadolinium agent into soft tissues during intravenous administration is less likely to result in serious complications.

Gadolinium Safety
Gadolinium safety became a major concern in 2007, when the U.S. Department of Agriculture mandated that all gadolinium contrast manufacturers add a black box warning regarding the risk of nephrogenic systemic fibrosis (NSF) for patients with acute or chronic renal insufficiency. Until that time, gadolinium–based contrast agents had been assumed to be non-nephrotoxic. Several studies have since determined the toxicity of gadolinium in patients with renal insufficiency and those with normal renal function. These studies also have shown that deterioration in renal function can occur in the majority of cases after intra-arterial administration of gadolinium–based contrast agents used at doses higher than 0.2 mmol/kg for diagnostic procedures in patients with renal insufficiency. According to the guidelines of the Contrast Media Safety Committee of the European Society of Urogenital Radiology, contrast-induced...
nephropathy is defined as acute renal failure after administration of contrast media when alternative causes of renal damage have been excluded. Contrast-induced nephropathy is the third leading cause of acute renal injury necessitating hospitalization. It typically is caused by iodinated contrast, but some gadolinium–based contrast agents are associated with contrast-induced nephropathies well, especially in patients with advanced renal disease. Because of this, most facilities now use the recommended dose guideline of 0.1 mmol/kg for non-vascular MR imaging studies, and this dose appears to be safe for most patients.

**Gadolinium Structure and NSF**

Other studies have revealed that the chemical structure of gadolinium–based contrast agents matters in the development of NSF, and the risk is much higher with nonionic linear chelates such as gadodiamide (Omniscan) and gadoversetamide (Optimark) because of the rapid release of gadolinium (dechelation) in these agents. Macrocyclic gadolinium–based contrast agents such as gadobenate dimeglumine (Multihance) are more resistant to dechelation and are considered to be more stable. However, it still is recommended that all gadolinium agents be given at the recommended dose level and only to patients with normal renal function. The incidence of NSF has decreased dramatically with the development of clinical protocols that restrict the use of gadolinium contrast in patients with impaired renal function.

**Intracranial Deposition**

Although NSF is becoming less of a concern, recent research suggests that intracranial gadolinium deposition can occur in patients with otherwise normal renal function. McDonald et al conducted a study on deceased patients to evaluate any correlation between deposition of gadolinium in neuronal tissues and repeated use of gadolinium–based contrast media. The study included a control group of 10 deceased adult patients who had received a noncontrasted MR imaging scan between 2000 and 2014 and a group of 13 deceased adult patients who had undergone at least 4 gadolinium-contrasted MR imaging studies during the same period. All patients received MR imaging of the brain, including an unenhanced T1-weighted axial sequence of the entire brain; a gadolinium-enhanced sequence also was performed, using gadodiamide. All studies involved the same MR technique parameters. Unenhanced T1-weighted signal intensities were analyzed from set anatomic regions of the brain. These areas of interest included the dentate nucleus, pons, globus pallidus, and pulvinar of the thalamus. Inductively coupled plasma mass spectrometry also was performed to measure tissue gadolinium concentration.

McDonald et al found that none of the members of the control group had detectable levels of gadolinium, but all patients who had been exposed to multiple doses of gadolinium contrast had elevated levels of gadolinium deposition in the 4 neuroanatomical regions examined. The dentate nucleus contained the highest concentrations of gadolinium, and some of the highest tissue concentrations of gadolinium were present in patients who had normal renal function. The authors concluded that intracranial gadolinium deposition is likely to occur in all patients who are exposed to as few as 4 lifetime doses of intravenous gadolinium contrast, regardless of renal function.

A similar study by Kanda et al evaluated the correlation between the number of previous gadolinium–based contrast doses and high MR signal intensity, specifically in the dentate nucleus and globus pallidus. The researchers compared MR images of 19 patients who had undergone at least 6 gadolinium-enhanced MR studies and 16 patients who had undergone at least 6 noncontrast MR studies. T1-weighted MR images of the entire brain were acquired on a GE 1.5 Tesla scanner, all using the same MR technique parameters and all without contrast enhancement. Two radiologists analyzed the images and measured mean signal intensity in the regions of interest. The authors noted a distinct correlation between multiple doses of gadolinium–based contrast administration and higher signal intensity in the dentate nucleus and, to a lesser extent, in the globus pallidus, which is independent of renal function.

**Functions of the Dentate Nucleus and Globus Pallidus**

The anatomic locations of the brain that seem to retain the greatest amount of gadolinium contrast are the dentate nucleus and the globus pallidus. The
dentate nucleus is located in the cerebellum, which is responsible for balance and coordination. The cerebellum consists of 2 cerebellar hemispheres comprising deep gray matter folds in the shape of a cauliflower. Within the center of each cerebellar hemisphere is a collection of cerebellar nuclei, the largest of which is the dentate nucleus. Fibers of the dentate nucleus project to the thalamus through the superior cerebellar peduncles. From there, the fibers travel to the motor areas of the cerebral cortex, thus influencing motor control.

The globus pallidus is part of the basal nuclei, which permits unconscious movements such as swinging the arms with the legs during ambulation. The globus pallidus consists of a group of output neurons, and the motor cortex transmits information to these nuclei at the center of the brain and to the cerebellum at the brain's base. The nuclei also send information back through the thalamus, which is located nearby.

**Chemical Structure and Intracranial Deposition**

The observed T1 hyperintensity might be a consequence of the dissociation of gadolinium from its ligand molecule. Because agents with macrocyclic structure cage the element in the molecule, the rates of dissociation of gadolinium from macrocyclic ligands are lower than dissociation from linear ligands and therefore are considered more stable. Several studies have suggested that the chemical structure of the gadolinium–based contrast agents is related to intracranial retention.

A study by Radbruch et al compared changes in signal intensity ratios of the dentate nucleus and the globus pallidus on unenhanced T1-weighted MR images between linear and macrocyclic gadolinium–based contrast agents to determine whether intracranial deposition was related to the type of contrast agent used. Examples of linear gadolinium–based contrast agents include gadopentetate dimeglumine (Magnevist), gadobenate dimeglumine, and gadoxetate disodium (Eovist). Examples of macrocyclic gadolinium agents include gadoterate meglumine (Dotarem), gadobutrol, and gadoteridol (ProHance). The researchers examined MR images of 50 patients who had been given at least 6 doses of linear gadolinium–based contrast agents and 50 patients who had been given at least 6 doses of macrocyclic gadolinium–based contrast agents. T1-weighted axial images were acquired using standardized MR technique parameters, and the areas of interest were analyzed by a radiologist. The signal intensity in the dentate nucleus and globus pallidus was compared with the intensity in the pons, cerebrospinal fluid, and cerebellum. The study showed increased signal intensity in the dentate nucleus and globus pallidus on unenhanced T1-weighted images in patients who had received several doses of the linear gadolinium–based contrast agent gadopentetate dimeglumine. However, no significant increase in signal intensity was shown on images of patients who had received the macrocyclic gadolinium–based contrast agent gadoterate meglumine. This was 1 of the first research studies to show that intracranial deposition is dependent on the type of gadolinium agent used and that some agents are safer than others.

An animal study published in 2015 by Robert et al also compared linear and macrocyclic gadolinium agents, with results similar to those found by Radbruch et al. Over a 5-week span, Robert et al injected multiple doses of the linear agent gadodiamide into 1 group of rats and multiple doses of the macrocyclic agent gadoterate meglumine into another group. T1-weighted MR imaging was performed once a week during this time. Gadolinium concentrations were measured using spectroscopy, and the authors found increased T1 signal intensity in the deep cerebellar nuclei, including the dentate nucleus, only in the group of rats exposed to the linear agent gadodiamide. These findings suggest that linearly structured gadolinium agents result in more intracranial deposition than do macrocyclic-structured agents, which is in line with the findings of McDonald et al.

Similarly, Ramalho et al also examined the signal intensity differences between types of contrast. They compared gadodiamide with gadobenate dimeglumine. These agents are linear in structure, but gadodiamide is nonionic and gadobenate dimeglumine is ionic. Group 1 included 23 patients who underwent gadodiamide–enhanced MR imaging and group 2 included 46 patients who underwent gadobenate dimeglumine–enhanced MR imaging. Two radiologists conducted a quantitative analysis of unenhanced T1-weighted images using

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region-of-interest measurements. The globus pallidus to thalamus signal intensity ratio, dentate nucleus to middle cerebellar peduncle signal intensity ratio, and relative change between the first and last examinations for each patient were calculated. The relationship between the signal intensity ratios and the number of enhanced MR imaging examinations also was analyzed. The study showed a significant increase in signal intensities associated with multiple doses of gadodiamide, the nonionic linear agent, but not with gadobenate dimeglumine, the ionic linear agent. This finding shows the differences in stability and elimination between the 2 contrast agents. Rate-of-change data indirectly also suggested that gadolinium deposition occurred in the dentate nucleus with gadobenate dimeglumine use, although considerably less than with gadodiamide. These results are useful to MR facilities because they show that ionic contrast agents can affect the amount of gadolinium deposition that remains in the brain and that although gadobenate dimeglumine might be safer than gadodiamide, it still might have gadolinium deposition associated with it. These results correlate with the findings of the studies by Radbruch et al14 and Robert et al15—that linearly structured gadolinium–based contrast agents might have a higher incidence of intracranial deposition than macrocyclic-structured agents, suggesting that the macrocyclic ionic gadolinium agent gadoterate meglumine might be the safest agent.

**Limitations**  
Gaps in the literature exist. Further research is needed to determine whether gadolinium retention is harmful to the body. Patients who have some level of deposition should be evaluated to determine the existence of balance and coordination issues as a result of gadolinium contrast retention. If so, the frequency and severity of these problems should be analyzed as well.

**Conclusion**  
Several research studies show that intravenous gadolinium contrast administration causes intracranial deposition, particularly in the dentate nucleus and globus pallidus, with as few as 4 doses of gadolinium contrast, and that this occurs regardless of renal function. It also has been shown that linearly structured gadolinium agents, such as gadodiamide and gadobenate dimeglumine, tend to have a much higher incidence of retained gadolinium than do macrocyclic-structured gadolinium agents, such as gadoterate meglumine, which showed no evidence of retained gadolinium. In addition, nonionic agents had a higher incidence of retained gadolinium in the brain than did ionic agents. On the basis of these studies, it can be concluded that the macrocyclic ionic contrast agent gadoterate meglumine might be the safest in terms of retained gadolinium.

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Ultrasound Safety: Can We Do Better?

Jennifer Bagley, MPH, RDMS, RVT

An article published in September 2016 captured national attention when the authors suggested that first trimester in utero ultrasound exposure was correlated with severity of autism spectrum disorder symptoms in genetically vulnerable children. That article was not the first to attempt to link in utero ultrasound exposure to autism spectrum disorders, but in this case, the evidence presented was based on uncertain methodology and not on rigorous testing. At least 2 other research studies indicate no causative association with autism spectrum disorders and in utero ultrasound exposure, and a comprehensive review of the evidence-based literature demonstrates no causal links between in utero ultrasound exposures and adverse fetal, neonatal, and childhood outcomes. Research widely indicates that the medical use of ultrasound during pregnancy is safe; however, because sensational headlines are likely to alarm the public, and because safety remains uncertain, professionals who perform sonography should renew their commitment to ultrasound safety.

The absence of a negative biological effect does not prove safety, and simply having a record of safety does not justify ignoring the known and theoretical risks of ultrasound, which include the ultrasound-induced biological effects of heat and cavitation. Heat has been demonstrated to have teratological effects on the fetus. Cavitation occurs in the presence of natural gas bodies, or more likely in gas body contrast agents introduced into the bloodstream during sonography examinations. Although cavitation is lethal in animal models and can induce cell apoptosis, its effects largely are negligible in fetal imaging. Therefore, heat remains the primary concern with fetal imaging.

Materials from the American Institute of Ultrasound in Medicine (AIUM) support no established cause and effect relationship between diagnostic sonography and adverse effects in humans. Because no research indicates a cause-and-effect relationship between in utero exposure and an adverse outcome, the AIUM recognizes the medical benefit of using ultrasound during pregnancy. However, it also recognizes that most epidemiology studies were performed using intensities before 1992, and thus we currently do not have much knowledge of the effects of current output. The lack of a demonstrated effect provides assurance that sonography is safe when performed for medical benefit by qualified and educated individuals.

Although the research is encouraging, sonographers must not lose focus with regard to ultrasound safety for 2 reasons. First, no literature studying the biological effects of sonography has safety as its hypothesis, nor does it report the results of clinical trials that address the cause-and-effect relationship between ultrasound exposure and adverse effects. Second, in 1992 the ultrasound community moved from examination-specific intensity limits to 1 global limit for all exposures. In the case of fetal imaging,
To simplify thermal index monitoring for sonographers, AIUM has proposed updated guidelines that indicate that obstetric sonography—when medically indicated—can be performed for an extended time safely if mechanical and thermal indices are kept below 0.7. Doing so enhances safety, regardless of total examination time, and clarifies how to interpret the indices during an examination.

The mechanical and thermal indices are not intended to replace operator judgment. Instead, they are to guide the sonographer in taking action and to limit exposure so that a quality diagnostic sonogram is obtained while mitigating potential risks to the patient. In addition to monitoring the safety indices, the sonographer should:

- Decrease output power at the beginning of each examination and increase only as needed.
- Use M-mode (ie, motion mode; measures motion over time, uses less power than spectral Doppler, and does not provide audio output) to take fetal heart rate.
- Avoid using Doppler imaging during the first trimester, except when refining for trisomy risk.
- Never use spectral Doppler to “listen to” the fetal heart beat during an obstetrical examination.
- Limit use of Doppler in the second and third trimesters to what is necessary for medical benefit to the fetus and then for as little time as possible.
- Move the transducer frequently so as not to dwell too long on fetal bone.
- Avoid dwelling on the fetal head to observe or document fetal profiles for parental keepsake images.

In addition, anyone who performs diagnostic sonography should earn the proper credentials in the specialty areas in which they work.

Patients should be discouraged from visiting fetal keepsake imaging centers because they expose the fetus to excess ultrasound energy for no medical benefit. Keepsake imaging centers might prolong ultrasound exposures unnecessarily, and they do not have to ensure that the operator is qualified to operate the equipment or to identify abnormalities. For these reasons, the U.S. Food and Drug Administration, the Society of Diagnostic Medical Sonography, and the AIUM discourage the practice of keepsake imaging.

Both mechanical and thermal indices are unitless numbers displayed on the monitor or on the ultrasound system during an examination. A mechanical index of 1.0 or greater indicates that scanning conditions are such that mechanical effects such as cavitation could occur. The thermal index is displayed similarly to the mechanical index but indicates that heat-related biological effects might occur. A thermal index of 1.0 indicates that conditions exist in which the temperature in tissues could be raised 1°C. The thermal index is further divided into 3 subcategories in soft tissue, which is appropriate to display in examinations that scan adult soft tissue as well as first-trimester fetuses of up to 10 weeks. The thermal index at bone should be displayed whenever bone is at focus and during fetal sonography performed at 10 weeks or more. The thermal index of cranial bone at surface is most appropriately displayed during a neonatal head examination.

Evidence suggests that those who perform sonography are not monitoring the mechanical or thermal indices for safety nor do they possess a basic understanding of them, including how to monitor them and where they are located on the systems. The lack of observable biological effects might give a false assurance of safety to operators and patients, which is concerning.
Every sonographer should be familiar with the AIUM’s biological effects and safety statements, which are updated as new scientific evidence develops. In addition, although educating oneself about the potential biological effects of sonography is a good first step, education must be reflected in practice. By monitoring the mechanical and thermal indices and following the recommended guidelines, sonographers can ensure they are performing the safest diagnostic medical examination for their patients while meeting the highest professional standards for safety.

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References


Prompt diagnosis of a scaphoid fracture is essential to maintaining long-term bone health and preventing disability. If neglected or misdiagnosed, a displaced scaphoid fracture can promote avascular necrosis or early onset osteoarthritis and lead to chronic pain and disability. The scaphoid view, a posteroanterior projection of the wrist positioned in ulnar deviation, often is requested for examinations of wrist trauma to identify possible scaphoid fractures.

The scaphoid bone, 1 of the 8 carpal bones in the wrist, articulates with the distal radius and 4 carpal bones (lunate, trapezium, trapezoid, and capitate). Its primary function is to transfer compression loads between the forearm and the hand. The scaphoid is the most commonly fractured carpal bone, in part because of its location among the carpals. It is situated in the proximal carpal row on the thumb side of the wrist and adjoins the distal carpal row. As a link between the 2 rows, the scaphoid helps maintain carpal stability.

When a hyperextension injury occurs, such as a fall on an outstretched hand, this places stress on the scaphoid and can lead to an acute fracture.

Identifying the location and severity of a scaphoid fracture is vital to providing appropriate treatment (see Figure). Three areas of the scaphoid can be fractured: the waist (70% of fractures), the distal end (20%), and the proximal end (10%). Fractures are classified according to location and degree of displacement. A fracture is considered unstable if displacement is more than 1 mm on a radiograph, if the scapholunate angle is greater than 60°, or if the lunocapitate angle is greater than 15°.

Elizabeth A Paterson, BS, R.T.(R)(CT)(M)
Precise positioning and central ray angulation are important for optimal demonstration of the scaphoid.\textsuperscript{2} A proper scaphoid view should demonstrate the bone without superimposition. In addition, adjacent carpal interspaces should be open.\textsuperscript{1} The bone should not be foreshortened, and ulnar deviation (ie, bending of the patient’s wrist toward the little finger side) should present the angle of the long axis of the metacarpals in alignment with the radius and ulna.\textsuperscript{1} To visualize the scaphoid borders, scaphoid fat stripe, and bony trabecular markings, the exposure should produce adequate density and contrast with no motion.\textsuperscript{3}

To achieve an optimal image, position the patient’s wrist on the image receptor with the palm down and the shoulder, elbow, and wrist on the same horizontal plane.\textsuperscript{3} Without lifting or rotating the distal forearm, gently move the patient’s hand as far toward the ulnar side as the patient can tolerate.\textsuperscript{3} The patient can use his or her other hand to assist in achieving optimal ulnar wrist deviation and minimize discomfort. Angle the central ray 10° to 15° proximally toward the patient’s elbow.\textsuperscript{3} The central ray should be directed toward the scaphoid, approximately 2 cm distal and medial to the radial styloid process.\textsuperscript{3} Collimate to the carpal region approximately 6 cm proximal and distal to the wrist joint and 2.5 cm on the sides.\textsuperscript{4}

Many patients with suspected scaphoid fractures have limited range of motion and cannot attain maximum ulnar wrist deviation. When this occurs, the angle of the scaphoid remains more anterior and can obscure the distal portion of the bone.\textsuperscript{5} To compensate for unwanted anterior tilt, increase the central ray angulation to approximately 20° to place the central ray perpendicular to the long axis of the scaphoid.\textsuperscript{5} Obscure scaphoid fractures might require several projections with different central ray angles or further evaluation with computed tomography or magnetic resonance imaging.

The scaphoid view can be challenging in the presence of wrist trauma and associated pain. However, precise positioning can ensure an accurate diagnosis and a better prognosis.

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No doubt about it, as imaging technology has improved, so has patient care. As a result, the use of medical imaging, especially computed tomography (CT), has increased during the past several decades, particularly with pediatric patients, and for good reason: CT provides information to help providers quickly and accurately diagnose injuries. It saves lives and often prevents the need for more invasive procedures. However, inappropriate use of CT—or any imaging tool that uses ionizing radiation—can result in unnecessary risks to patients, particularly children.

In 2001, several scientific articles claimed that pediatric patients who underwent CT procedures received estimated radiation doses as much as 3 times higher than those given to adults. Similar articles about the risks of overreliance on CT soon followed, spurring the need to implement a balanced approach to scanning the pediatric population that weighed the health benefits of CT with the known risks. In 2008, the Alliance for Radiation Safety in Pediatric Imaging, a coalition founded by the American Society of Radiologic Technologists, the Society for Pediatric Radiology, the American College of Radiology, and the American Association of Physicists in Medicine, made a notable effort to strike that balance with the launch of the Image Gently campaign.

The campaign includes information about pediatric imaging examinations directed to radiologic technologists, medical physicists, radiologists, pediatricians, and parents. It also offers protocols for reducing pediatric radiation dose during CT examinations. In 2014, Image Gently introduced new protocols to address the additional innovative features installed in CT scanners since 2008, such as automatic tube current modulation, reduced tube voltage techniques, and iterative reconstructions. The 2014 protocols provided guidance for setting up techniques for newborns, children, and adults and for acquiring diagnostic-quality images using well-managed radiation dose levels regardless of CT scanner manufacturer and model. Thousands of individuals and facilities have joined the effort and taken the pledge to image gently when performing pediatric radiologic examinations.

Building on the success of the Image Gently campaign, the Alliance launched the Think A-Head campaign in November 2016. The key drivers of the campaign’s development include the frequency of head trauma in children, the prevalence of CT use (it is the most common examination performed in children), and the wide variability in levels of radiation dose used in pediatric scans across the United States. The initial goal of the campaign was to offer information that would help providers determine whether a CT scan was the best option for diagnosing children with minor head injuries. It quickly expanded to include eliminating low-value procedures as well as establishing and following age-appropriate protocols for when scans are necessary.
The campaign’s tools and resources help providers ensure that they are complying with the latest evidence-based medical guidelines regarding performing CT scans on children with minor head injuries. The material also is useful in helping the patient care team—from providers to parents—communicate in an informed manner about why the scan is or is not necessary and how to make the best-informed decision possible (see Box). ⁴

The importance of optimizing dose has long been a guiding principle in the imaging profession, signified by technologists’ staunch commitment to the as low as reasonably achievable (ALARA) principle. Regardless how technology evolves, what must never change is the focus on patient care—something diagnostic imaging professionals are passionate about. Although it is challenging to be the technologist asked to perform a CT scan on a pediatric patient when it is unclear what is best for that patient, information from campaigns such as Think A-Head offer additional tools to open a dialog with physicians and others to help ensure the best care for their patients.

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**To learn more about Image Gently initiatives, visit imagegently.org.**

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**Emilee Palmer, BS, R.T.(R)(CT), is imaging supervisor for OhioHealth Westerville Medical Campus. She also is a member of and ASRT representative to the Think A-Head campaign committee.**

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The EOS Imaging System: Promising Technology in Skeletal Imaging

Annette Ortiz, MA, R.T.(R)(CT)

The global medical device company EOS imaging offers a full-body, low-dose stereoradiographic imaging system that is transforming diagnosis, surgery, and treatment for the most common osteoarticular conditions (ie, hip, knee, and spine). It is the only technology of its kind on the market. Tailored for orthopedic imaging, the EOS imaging system produces 2-D radiographs of the body in an upright position. From the 2-D images, supplementary EOS software generates patient-specific 3-D measurements and models of the skeletal system that can inform all facets of clinical care.

The first EOS imaging systems were installed in North America and Europe in 2008, and today they are available in 51 countries, including the United States, China, and Japan.

The EOS imaging system is based on the scientific research of French physicist Georges Charpak, who received the Nobel Prize in Physics in 1992 for his invention of a gaseous particle detector with a multiwire proportional chamber. His chamber increased the detection of particle collision events by the millions per second, vs the detection of 1 to 2 per second with earlier detectors. Physicists, engineers, radiologists, and surgeons built upon Charpak’s research in radiation detection, leading to the development of the EOS imaging system. The system uses a multiwire proportional chamber detector to detect x-rays, thus serving as a measurement of ionization that helps minimize radiation exposure to patients.

As with conventional radiography, the EOS imaging system primarily is an imaging tool for the skeleton. However, unlike a standard, single-source x-ray beam, the biplanar EOS system uses 2 perpendicular fan beams that vertically scan the body, producing 2 simultaneous frontal and lateral images of the entire skeleton. Radiographs are taken while the patient is standing to visualize the skeletal system under normal weight-bearing conditions. The EOS imaging system is equipped with the sterEOS workstation. This workstation uses statistical modeling and bone-shape recognition software to produce 3-D measurements of frontal and lateral images and 3-D reconstructions of the spine and lower limbs. For that reason, the system is like computed tomography (CT) imaging but does not provide information on soft tissues such as muscles, spinal cord, nerves, and viscera.

The EOS imaging system uses a standard low-dose protocol. In a study comparing EOS imaging to computed radiography (CR) imaging of the spine, Deschênes et al found that the entrance skin dose was 3 times lower for the nape of the neck and 6 to 9 times lower for the thoracolumbar region when using the EOS system. In addition, the researchers found that overall image quality was enhanced compared to CR, but that the latter demonstrated the lumbar spinous processes better than did the EOS system. Further, Delin et al found that using CT for 3-D reconstruction of femoral and tibial torsion measurements resulted in 4.1 times...
higher ionizing radiation dose to the ovaries, 24 times higher dose to the testicles, and 13 to 30 times higher dose to the knees and ankles compared to dose exposure when using the EOS system.\(^4\,9\)

In 2015, EOS introduced a microdose protocol option to further minimize radiation dose to pediatric patients and others who require repeat radiography examinations.\(^4\,9\) In the radiological follow-ups of 32 adolescent patients with idiopathic scoliosis, Ilharreborde et al found that the microdose protocol resulted in 5.5 times lower radiation exposure than did the standard EOS low-dose protocol, equating to a 45-fold reduction in radiation compared to conventional radiography.\(^10\)

The researchers also concluded that the microdose protocol did not alter the quality of images.\(^10\)

EOS imaging might be most useful for evaluating and monitoring scoliosis and sagittal balance because it performs simultaneous orthogonal imaging while the patient is standing, and it also can demonstrate relationships with the adjacent cervical spine, pelvis, and lower limbs.\(^4\) Using the EOS imaging system, Vidal et al assessed the reliability of radiographic measurements for global sagittal balance and sagittal spine curves.\(^11\) The researchers evaluated full-spine EOS radiographs of 50 patients with adolescent idiopathic scoliosis (AIS) and 25 normal controls.\(^11\) The patients with AIS were divided into 2 groups: 25 had not had surgical correction and 25 had undergone posterior arthrodesis surgery. Each patient was scanned with the EOS imaging system while standing in a standardized position defined by looking straight ahead with his or her fists on the clavicles. Vidal et al concluded that cervical lordosis and global sagittal spine balance in AIS could be measured using a simple and widespread tool such as the EOS imaging system.\(^11\)

In addition, they concluded that the EOS imaging system can obtain large, full-spine radiographs while delivering significantly reduced levels of radiation exposure. They found no issues with image quality among the 75 patients.\(^11\) Their findings are particularly meaningful for patients who have AIS and require repeated radiographic follow-up. Studies using the EOS imaging system to assess cervical spine changes in patients who have AIS after corrective surgery are needed.\(^11\)

EOS imaging technology offers medical institutions many advantages, but it also has limitations:\(^4:\)

- Wavy image results if the patient is unable to stand or sit with steadiness.
- Reduced contrast in 2-D images compared to the contrast in conventional radiographs.
- 3-D reconstruction is semiautomatic, thus increasing the risk of error.
- Available software cannot perform 3-D reconstruction when imaging children younger than 6 years because the software was designed for adult bones.
- 3-D reconstruction of the patella, rib cage, and congenital anomalies of the spine is not possible.
- Biased measurements can result when imaging severe deformities of the limbs with the 3-D angular measurement because it uses a statistical model based on “normal” bones.
- Unlike CT imaging, in which many acquisitions are performed to generate the axial view, EOS 3-D reconstruction encompasses only the outer bone surface and not the inner structure of the bone.

Despite its limitations, EOS imaging is a valuable research tool and gradually is replacing conventional digital radiography in some clinical settings because of its low-dose technology and precise 3-D imaging capabilities.\(^4\) Given its diagnostic benefits and usefulness in follow-up treatments, the popularity of EOS imaging likely will increase as research teams continue to improve the technology.

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A Protégé’s Guide to Working With the Perfect Mentor

Christopher Bullister, AAS, R.T.(R)

Used responsibly, mentoring is a tool that can take the weakest of mankind to the ends of the earth. Everyone is influenced by the culture, people, and experiences encountered throughout his or her lifetime. Inexperienced protégés can seek advice and guidance from those who are more experienced. However, simply finding a mentor is not the only key to success. It is important to understand the qualities of a good mentor, the necessary willingness of a protégé, and the ultimate end goal of the relationship.

Finding a mentor on whom you can rely can help open the doors for emotional support, career advice, and technical and procedural knowledge related to your field. According to Ensher and Murphy:

Mentors can help you clarify your work expectations, give you an opportunity to do your best, enable you to receive recognition and praise, make you feel cared about, encourage your development, make you feel like your opinions matter, provide you with a friendship at work, talk to you about your progress, and provide opportunities for you to learn and grow.

Protégé–mentor relationships are delicate, but when a successful pairing is made, the benefits can be lifelong.

Finding a Mentor

Whether you are a student, a technologist, or an educator, there are a few things to consider if you are looking for a mentor. First, take the initiative to find a mentor rather than waiting to be chosen. You can search for the best minds in your profession, whether they reside locally or worldwide, through periodicals, conferences, or over the Internet. Local options might include educators, program directors, and staff at clinical rotation sites. Leaders of your state affiliate society, senior technologists, department managers, and those certified in a modality you are considering pursuing also might be good mentors. Once you identify a person from whom you would like to learn, explore his or her accomplishments, business profiles, and publications. You might even look someone up on social media. After connecting with a potential mentor, ask yourself whether he or she:

- Makes you feel important.
- Makes you feel as though your opinions matter.
- Takes the time to listen to you.

If the person makes you feel as though your development and quality of work is not a priority, you might want to look elsewhere.

Adding a Personal Touch

I was fortunate enough to be assigned a mentor over the past year for the American Society of Radiologic Technologist (ASRT) Student Development Leadership Program. The organization seemed to choose their mentors wisely, which is important when trying to lead the next generation in the field of radiologic technology. It is important that a
mentor sparks a protégé’s learning and development in work and in life.

In my experience, asking questions was extremely helpful because it established open communication. As a protégé, you have the right to ask; however, it is important to limit questions and requests to what you really want or need answered in an effort to respect your mentor’s time and commitments.¹

Building a Rapport

Building a rapport and a sense of comfort with a mentor usually results in increased willingness to listen and learn. However, developing a relationship takes time, and it is important to gain trust on both sides. In the beginning, you should gauge whether your potential mentor truly has a passion for his or her role. If mentors show no enthusiasm for their work or appear to be disengaged, it is a red flag to how well they will encourage you.

Being a Good Student

Learning how to become a good protégé is another step you must take to have a successful mentorship. Are you ready and able to be mentored? You should “[k]now what you want, know how to get what you want, know how to build and deepen the relationship.” As a protégé, I wanted to learn because the ones who ultimately would benefit from the knowledge I gained were my future colleagues and, most importantly, the patients.

The 9 steps to becoming a protégé are¹:

- Participate.
- Take responsibility.
- Observe.
- Ask.
- Chart your course.
- Network.
- Take informed risks.
- Reflect.
- Give back.

One key step is to reflect. One of the best ways to learn is to take the time to step back and evaluate what, why, and how you learned. I find this step critical for learning and using this knowledge to influence growth in the next step forward. This list also helps mentors set expectations for and with new students.

Giving back is the last step in any successful mentorship.¹ Former protégés can share their enthusiasm with newcomers who enter the workforce after them. Being passionate and having a desire to spread your knowledge allows you to begin leaving your own legacy that will carry on.

Leaving a Legacy

As a recent graduate from a radiologic technology program, I continue to work in an environment with students. I have proudly taken on the informal role of mentor with students and have begun developing relationships with those who are eager to learn. Many people do not realize that¹:

[M]entors and protégés exchange valuable, albeit different, benefits with each other. Although the exchange might be very different, the exchange has to be seen as equally valuable and reciprocal for both parties involved.

This statement speaks to me, and now I can look at every learning experience as beneficial not only for the student but also the teacher.

Those who are passionate and possess a desire to spread knowledge have the greatest influence. These people also know the crucial roles both mentors and protégés have in the partnership’s success. It is, in a sense, a 2-way street between teacher and student, sensei and grasshopper, leader and follower. The question to ask now is: How much will you take out of your next experience?

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References
The Pros and Cons of Writing With Coauthors

Kelli Welch Haynes, MSRS, R.T.(R)

Sally Mae has an idea for a journal article, and her friend, Mary Jo, needs to publish articles to meet her productivity requirements for work. Both are hesitant to attempt writing alone. They are not sure of the process, fear rejection, and are concerned about the workload. They decide to write an article together and settle on a topic: mating habits of a particular bird species found mainly in the south. However, trouble in paradise quickly arrives. Sally Mae wants to focus on the mockingbird, and Mary Jo believes the brown pelican is more appropriate. After much gnashing of teeth and some name calling, they decide that the mockingbird has a more universal appeal. The main topic of the article is established.

Because the article idea and subject are Sally Mae’s, they agree that she will take the lead as first author, directing the flow of the article and the writing process, as well as submitting the final draft. Mary Jo will contribute to the publication as directed by Sally Mae. After some discussion, it is decided that Mary Jo will begin the literature review process, while Sally Mae focuses on obtaining original research data for the body of the article. Mary Jo completes her section in a timely manner, but because Sally Mae is juggling numerous projects with urgent deadlines, her portion remains unfinished. Mary Jo becomes frustrated at the lack of progress. Once again, tempers flare. Sally Mae, realizing that her procrastination is responsible for Mary Jo’s frustration, tries to make it up to her by diving into her assigned sections with vigor. The article eventually is finished and is viewed as a publication success.

At the end of the collaborative writing process, the 2 authors (who are still friends) better understand the pros and cons of working with coauthors on an article. They agree to collaborate again in the future.

The Collaborative Writing Process

Approximately 15% of technologists with doctorate degrees produce most of the scholarly research and writing in the radiologic sciences, but even this well-educated group faces difficulties with the process. For many, the publication process is one of the most daunting and time-consuming tasks an individual can attempt, which might explain why so few within the medical imaging and radiation therapy profession attempt to publish. Other reasons include a lack of research skills, lack of writing ideas, lack of time, difficulty with coauthors, or fear and anxiety of failing. Collaborative writing is seen as 1 solution to overcoming these barriers and to increasing scholarly productivity.

One of the first questions to address before starting a writing project is whether to work alone or with 1 or more coauthors. Evidence suggests that a greater proportion of articles today are team-authored rather than written by an individual. For most professionals, working in teams improves the quality of research. Not only does it bring together people with complementary
areas of expertise, but it also can provide greater depth regarding idea generation and refinement and shares the manuscript writing and revision duties among multiple authors. In addition, working with coauthors can be personally rewarding. However, it also can be frustrating.  

**Pros of Collaborative Writing**

One of the many advantages to working with coauthors is that 2 heads are better than 1. Having someone to consult with on a project can result in a better product. In addition, many hands can make light work. The most daunting writing project seems manageable when divided among 2 or more colleagues.  

Spreading the work among coauthors permits busy people, who might not otherwise find the time for a project, to join in a cooperative effort to produce a product. Coauthors can add missing components to the writing process, as well as provide peer support and feedback on writing. Finally, putting together a team of reputable coauthors can lend weight to the project because readers gravitate toward articles and books that bear the names of authors with whose work they are familiar.

Coauthors should be chosen strategically based on the knowledge or skill set they bring. For example, if the paper is an original research article with a data set component, then 1 or more authors should be comfortable with data analysis. By working with coauthors, writers gain new skills as they learn from one another and take on different roles within the writing process.

Trust is one of the most important factors in successful collaborations; it is difficult for a team to succeed without it. If coauthors do not trust one another, they can begin to question one another’s motivations and actions in every situation. Essential goals include developing a shared vision and clear expectations, sharing recognition and credit, handling conflict, building a good team, and enjoying the process. Open, honest, and respectful communication is critical to achieving those goals, and the most successful collaborations maintain good communication throughout the project.

Mentoring is another valuable component of the writing and research process. In the most successful situations, at least 1 member has had at least 1 article published and is able to direct the group through the obstacles and pitfalls of the writing process, keeping the group focused and motivated. Once the first collaborative project is complete, many groups choose to rotate roles, including the role of first author. By convention, the first author shoulders the greater workload and, as a result, receives the greater credit.

For radiologic science educators and other technologists who feel pressured to publish by their employment institutions, the increased productivity that coauthoring offers is a valuable commodity. For example, authors within the writing group might increase their publications as first authors from 1 to 10 publications over a 3-year period. This productivity increase is possible when coauthors appropriately distribute the workload, draw from one another’s strengths, and provide one another with the motivation and support needed to finish the project.

**Cons of Collaborative Writing**

Balanced against the benefits are the challenges that potential coauthors should consider. First, although 2 heads are better than 1, if the heads do not agree, there can be trouble, even stalemates. This is especially true for projects that require work over a long period. Second, although many hands can make light work, 1 pair of hands often does more of the heavy lifting. Rarely will all hands work with equal diligence or energy all the time. And third, having coauthors almost always requires more cooperation, greater patience, and increased willingness to pick up the slack. If any of the coauthors lack these characteristics, it can lead to tension as well as late manuscript submissions.

Effective collaborative writing is a gradual process. Rarely do coauthors produce immediately, instead requiring time to “gel” as a group. Trust must be built, egos must be subjugated, and free riders must be dumped. This building of a cohesive writing group can be described as a professional friendship, one in which reliability, openness, sharing, respect, and support are expected. The qualities of a professional friendship are helpful when combating the cons of collaborative writing because even with the best intentions, collaborative writing projects go awry. Differences in writing styles, productivity timelines, and attitudes can create the greatest challenges; other barriers include:

1. Open, honest, and respectful communication is critical to achieving those goals, and the most successful collaborations maintain good communication throughout the project.
2. Effective collaborative writing is a gradual process. Rarely do coauthors produce immediately, instead requiring time to “gel” as a group. Trust must be built, egos must be subjugated, and free riders must be dumped.
3. This building of a cohesive writing group can be described as a professional friendship, one in which reliability, openness, sharing, respect, and support are expected.
4. The qualities of a professional friendship are helpful when combating the cons of collaborative writing because even with the best intentions, collaborative writing projects go awry. Differences in writing styles, productivity timelines, and attitudes can create the greatest challenges; other barriers include:
Unequal perceived power differentials inherent in team membership (e.g., senior-junior faculty, dissertation chair and doctoral candidate, published author and unpublished team member).

- Failure to recognize others' contributions.
- Coauthors who fail to do their share.
- Writer's block.
- Domineering or feuding coauthors.

Many of these barriers can be overcome with communication and greater attention to interpersonal social skills. Trust building, conflict management, and individual accountability are keys to success with any collaborative project.  

**Conclusion**

Many articles about the pros and cons of collaborative writing include a list of mandates coauthors can use to achieve a successful and productive outcome. Brainstorming ideas and eventually agreeing on a chosen topic is of primary importance for any writing project. All selected members of the group should be considered unique and valuable, with equal valuing of member input and respect throughout the activity. Allocation of subtopics and identification of author placement, including identifying first author, should be next on the list. Members should create deadlines for each stage of the writing process and then meet those deadlines, with some understanding that responsibilities outside the project might interfere. Finally, communication that occurs at suitable intervals will help keep the project on track and minimize miscommunication.  

Collaborations are valuable to the pursuit of science and usually are personally rewarding. They are a great way to learn new methods, make friends, and have enriching experiences. Potential problems should be diffused before they detract from the value and fun of the science.

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Cheryl DuBose, EdD, R.T.(R)(CT)(MR)(QM), is assistant professor and magnetic resonance imaging program director for Arkansas State University in Jonesboro, Arkansas. She is president of the Association of Collegiate Educators in Radiologic Technology and past-president of the Arkansas Society of Radiologic Technologists. DuBose serves as an American Society of Radiologic Technologists Magnetic Resonance Chapter delegate and on the Radiologic Technology Editorial Review Board.

Kelli Welch Haynes, MSRS, R.T.(R), is associate professor and program director of the Bachelor of Sciences in Radiologic Sciences program for Northwestern State University in Shreveport, Louisiana. She is resident-elect of the Association of Educators in Imaging and Radiologic Sciences and past president of the Louisiana Society of Radiologic Technologists. Haynes also serves on the Radiologic Technology Editorial Review Board.

**References**

I often hear people talk about advocacy, but many do not understand what being an advocate means. The dictionary defines an advocate as someone who goes above and beyond for something he or she believes in or is passionate about.

In my opinion, radiologic technology is the best profession in which to work. I have been a registered technologist (R.T.) for almost 40 years, and I have been an advocate for most of those years. Early in my career, I educated others about my profession, letting them know what a great job I had, but that was the extent of my advocacy efforts. I did not realize there was a need for more—but even if I had, I did not have time to participate. At the time, I did not realize that sharing my passion for the profession was a form of advocacy. I had not considered that my fellow radiologic technologists and I acted as advocates every day simply by practicing patient and radiation safety and liaising between patients and radiologists. If I could turn back time, I would join my state affiliate and participate with the American Society of Radiologic Technologists (ASRT) as much as time allowed. Today, I tell everyone who will listen that whether you can give an hour a week or an hour a month, volunteering for the profession is critical because it strengthens our community of radiologic science professionals.

I also tell them that they do not have to go it alone. The ASRT and state affiliate societies have resources, materials, and advocacy experts to help. Advocacy is what these organizations are all about, and whether you are a member of ASRT, your state affiliate, both, or neither, it is important to know what they do for you. They are your advocates; they speak on behalf of you and your profession. They not only advocate for you in matters of licensure, but they also create—with input from volunteers throughout the R.T. community—guidelines that make up the foundation of the profession and help guide and govern R.T.s in their daily work.

Advocacy also helps us assure patients in every state that anyone who provides medical imaging studies is prepared educationally and clinically competent to do so. This is critical when you consider that it seems like every day, another group is trying to encroach on radiologic technology. For example, advanced practice registered nurses recently campaigned that it is within their scope of practice to “order, perform, supervise and interpret” medical imaging studies. Advocates in Kentucky and Massachusetts helped defeat this encroachment by having technologists actively involved in radiology legislative affairs in the states.1,2

My state, Missouri, is one of the few without state licensure or regulation of individuals performing imaging procedures.3 Advocacy helps maintain our profession and ensure that our patients are safe. On the national level, ASRT is working to put in place the Medicare Access to Radiology Care Act (MARCA), which would give mid-level radiology providers an equal status with other mid-level providers, such as physician assistants.4 ASRT
My Perspective

Diane Hutton, BA, R.T.(R), is adjunct clinical instructor for Washburn University in Topeka, Kansas. She also is a senior board member of the Missouri Society of Radiologic Technologists and its legislative activities chair. She may be reached at diane.hutton@mosrt.org.

Reference


Being a medical imaging professional provides you with a means of being an advocate. We serve our patients each day; I challenge you to serve your profession as passionately as you do your patients. There are many opportunities for you. If not you, who will step up to advocate for your profession. It takes all of us. Join with me and others to serve while we advocate for the profession we love.

also provides resources and assistance for state affiliates to maintain their legislative watch, which ensures that state efforts remain on the radar and can be addressed promptly.

Whether on the state or national level, it takes all of us to act. We can maintain our profession and ensure its integrity if we stand together and speak on behalf of what we do, but it takes advocates. Much like the saying, “if you don’t vote, you shouldn’t complain,” advocacy gives you a voice to make a difference in the areas that matter to you. You do not need to be a public speaker, travel extensively, or have a lot of money to advocate. Advocating is a win-win situation, with the biggest winners being our patients. The public needs to see our passion for our profession. For my fellow Missourians and me, being an advocate means going back to Jefferson City again and again until we get state licensure passed. For all R.T.s throughout the country, being an advocate means going back to Washington, DC, to get MARCA passed to promote care for patients. Being an advocate means we all go that extra mile, attend that extra lecture, and have that extra conversation to get our point across. I tell everyone that state licensure in Missouri is about the patients who need radiology services. Our patients expect and deserve quality care provided by educationally prepared and clinically competent individuals. It is the right thing to do, and that is what being an advocate is about: showing our passion and serving patients to the best of our ability.

The best calling in life is to serve, and a great way to serve is through advocacy. If you are ready to serve but are unsure where to start, consider these options:

- Educate yourself about issues that affect the profession and your state.
- Become a member of your state affiliate.
- Attend state affiliate or national conferences.
- Contact state lawmakers and let them know that all health care professionals who perform medical imaging should have specialized education, supervised clinical training in medical imaging procedures, and quantifiable competency assessment through examination.
- Know what your membership organizations stand for.
- Join an ASRT advocacy committee.
A nyone who has played with a hand-held magnet and iron filings has been exposed to the simplest version of ferromagnetic physics. Ferrous materials are highly susceptible to magnetization, and the degree of susceptibility depends on the strength of the magnetic field. From such humble physics stemmed magnetic resonance (MR) imaging and, shortly thereafter, the metallic artifact. Years later, metallic artifacts continue to wreak havoc on image quality.

At the Mind Research Network in Albuquerque, New Mexico, imaging is collected for nonclinical research purposes. Artifacts that interfere with data quality introduce unwanted outliers into the data pool. For the research to be valid, the imaging data collected from all participants must be uniform.

Figure 1 was collected on a Siemens Magnetom Trio 3.0-Tesla MR imaging system using the 32-channel head coil. The entire facial anatomy was obscured on the sagittal localizer because orthodontic braces caused a signal loss. The axial distortion correction sequence shows similar signal loss until the slices are well past the orthodontic appliances and into the midbrain (see Figure 2). Because artifacts like these are outside of the standard imaging requirements at the Mind Research Network, the imaging protocol must be discontinued when they occur.

In the clinical setting, where medical imaging aids in diagnosis, the radiologic technologist, radiologist, and requesting physician work together to determine different imaging sequences or a different imaging modality altogether to mitigate artifacts and produce the best
possible images. Imaging for research purposes does not allow for this type of customization to achieve the desired result.

In the case of orthodontic retainers and other appliances that contain less metal, it often is possible to minimize or eliminate the presence of the artifact in the scan field of view by changing the orientation or the sequence parameters. The placement, volume, and ferromagnetic susceptibility of the metal appliance will determine the extent of the artifact. The ability to mitigate the artifact lies in successful application of MR imaging knowledge and technique.

Figure 2. Axial distortion correction sequence showing signal loss until the slices are past the orthodontic appliances and into the mid brain. Image courtesy of the author.

Cathy Smith, R.T.(R)(CT), is a research technologist for the Mind Research Network in Albuquerque, New Mexico.
Thoughts on Shielding

Compton Scatter Concerns

Dear Radiologic Technology Editorial Review Board,

I read with great interest the peer-reviewed research regarding gonadal shielding, radiation dose, and best practice in the November/December 2016 issue of Radiologic Technology (Vol. 88, No. 2).

I would agree with most of the assumptions of the study. However, exposures in the milligray range that result in scatter in the microgray range are at least in the range of thousandths (1000th) of the primary beam dose.

Such low energy Compton scatter is of borderline significance when compared with using proper collimation and appropriate kilovoltage peak (kVp) and other exposure factors in the examination of an actual patient.

In addition, a possible limitation not mentioned in the study is the Compton scatter radiation from the table and the image receiver. I feel that the Compton scatter from the image receiver and table construction could be of greater significance than either the leakage, in air kerma dose, or off-focus radiation all originating from the tube side. This radiation already is being reduced significantly by the required aluminum filtration on the diagnostic x-ray tube required by the National Council on Radiation Protection and Measurements rules.

This unmentioned source of Compton scatter radiation caused by Compton scatter from the phantom and remnant Compton interaction of the aforementioned equipment structures could, in theory, be diminished greatly by simply placing a second flat lead shield between the phantom and the table top.

This could prove to be more effective and more practical than attempting to fix a cup-type lead shield to a male phantom pelvis in future research. In addition, this second flat shield placement, in my opinion, should be considered in any best practice scenario regarding flat lead shielding and patient dose.

In closing, I wish to commend the researchers on a study that required a lot of careful thought and hard work. This sort of dedication will contribute significantly to the on-going quest of the profession to conform to the principles of ALARA as much as is humanly possible.

John A Garner, PhD, R.T.(R)
Terre Haute, Indiana

The Author Responds:

I appreciate the feedback from Dr. Garner and agree that gonadal shielding along with collimation and appropriate kVp will further minimize the radiation exposure to the testes. I acknowledged the low-level gonadal exposure and compared the microgray exposure to millirads because millirads are a more familiar exposure unit for radiologic technologists. However, consistent with the linear
nonthreshold dose response, reducing even very low radiation exposures could lessen the potential for biologic risk.

Authors Daniels and Furey stated that contact shields, when located outside the primary beam, can only protect from leakage and external scatter radiation. Therefore, internal tissue scatter was the focus of this investigation. I acknowledge that backscatter might also be a contributory factor. Further research to investigate the advantage of posterior shielding is warranted. However, the research literature indicated that misplacement of the anterior gonadal shield can be problematic. Therefore, misplacement of a posterior gonadal shield could also be problematic.

Dr. Garner and I both agree that gonadal shielding is a best practice and reducing low-level patient radiation exposure is consistent with ALARA.

Terri L Fauber, EdD, R.T.(R)(M)
Richmond, Virginia

Encourage Students to Speak Up

I write in reference to the manuscript titled “The Need for Shielding Is Undeniable” in the November/December 2016 issue of Radiologic Technology (Vol. 88, No. 2). As a medical imaging practitioner and as a researcher and author on the topic of radiation safety, I find the authors’ investigation of the topic highly relevant, especially the need for radiography students to speak out when they witness unsafe work practices. I do, however, have concerns about the way this study was conducted for the following reasons:

1. One of the authors stood directly behind the x-ray tube at a distance of approximately 12 inches (0.3 m) from the x-ray tube of a mobile digital radiography unit during an anteroposterior chest examination. The most effective form of protection for radiographers is distance. Standing at a distance of 6 ft to 7 ft (2-2.13 m) reduces a radiographer’s radiation exposure to a negligible level. Distance would be the most appropriate protection method to teach to students in mobile radiography, performing the examination with the exposure button cord at full length from the unit. I am in no way discouraging the use of lead aprons by medical imaging staff.

2. The same author knowingly exposed their unshielded body part (hand) to ionizing radiation as a measurement tool in an experiment. It would have been more appropriate to conduct the experiment in a controlled environment using dosimeters as a means of measurement. Was the study approved by an ethics committee? If not, it contravenes section 3.152 of the International Atomic Energy Agency Safety Standards and quite possibly breaches U.S. federal and state Occupational Safety and Health Administration and/or radiation protection laws.

3. The examination in this experiment was performed by a student. It is the responsibility of the supervising radiographer to give their undivided attention to the examination being performed by a student radiographer—anything less has the potential to result in an unwarranted repeat exposure to a patient in their care.

As stated in the manuscript, “applying principles of ALARA to minimize exposure to patient, self, and others” are within a radiographer’s scope of practice. The methodology that was employed to conduct this study does not minimize exposure to the author. As medical imaging professionals, we need to teach our students valid and ethical research methodology. The experiment in this study is one of those instances in which I would have told a student to speak out.

Gary Denham, BMedRadSc, MMedRadSc
Taree, New South Wales, Australia

The Author Responds:

Mr. Denham brings up some great points. The authors agree that students should be taught valid and ethical research methodology. In the future we will consider controlled experiments as suggested with approval from an ethics committee using the International Atomic Energy Agency Safety Standards as its guidelines.
The authors believe they acted within the American Society of Radiologic Technologists Radiography Practice Standards, specifically the Radiography Clinical Performance standards (4), specific criteria for the radiographer (1 and 2) regarding radiation safety and ALARA. The authors further believe they also were in compliance with the American Registry of Radiologic Technologists Standards of Ethics (4 and 7 explicitly).

In response to the 3 specific concerns:

1. The original intent was to perform several experiments from various positions. The placement of the author for the exposure was felt to be the most common practiced position of exposure by a technologist with a student. It was decided this one exposure provided enough information from which to base the article.

2. The author conducting the experiment did nothing outside of standard practice other than place a device to measure exposure in a position to do so. During portable examinations, hands often hold the exposure switch and are not protected by a shield. In this isolated instance, a computed radiography cassette was placed to record the exposure. Though it was not approved by an ethics committee, it was approved by the department director and deemed not outside of standard practice.

3. There was an ARRT registered radiographer supervising the students during the examination.

Finally, the goal of the article was to point out the exposure of scatter to a student and radiographer while they perform portable x-ray examinations at a suboptimal distance when not wearing a lead apron.

**Sandi Watts, MSHA, R.T.(R)**
Carbondale, Illinois

**Matthew Cardinal, MEd, R.T.(R)**
Forsyth, Illinois

**References**


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What’s Inside?

Historically used in mammography, xeroradiography is a type of x-ray imaging in which a picture of the body is recorded on paper rather than on film. Although beneficial in the diagnosis of breast tumors, the process can require higher doses of radiation and, with the advent of digital mammography, is used rarely in current practice. Image courtesy of the ASRT Museum and Archives.

The absence of a negative biological effect does not prove safety. Read more on Page 440.

Approximately 50% of MR studies worldwide are ordered with contrast. Read more on Page 435.

The use of CT has increased with pediatric patients in recent years. Read more on Page 446.

15% of technologists with doctorate degrees produce most of the scholarly research and writing in the radiologic sciences. Read more on Page 453.

The scaphoid is the most commonly fractured carpal bone. Read more on Page 444.

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