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ON THE COVER
“Gradually 2014” is the first cover by Bergés Alvarez, MD, R.T.(R)(T)(QM), of Bellmore, New York. “I do not have formal training or an art history major, but in medicine and science I have found a true art form that I can call my own,” he says. Alvarez uses light and reflective surfaces such as x-ray films to create his images.

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This symbol indicates expanded content in the online edition of Radiologic Technology at www.asrt.org/publications.
A New Year

Alicia Kellogg, MA

Each year as summer officially turns to fall, the beginning of October marks the start of National Breast Cancer Awareness Month. Pink is especially prevalent this time of year, as the breast cancer awareness movement has reached the point where the color itself conveys the message. In one of this issue’s Directed Readings, author Teresa Odle examines another important health concern among the female population that, despite common perceptions, is the No. 1 killer of women: heart disease.

As Odle addresses in her article, organizations such as the American Heart Association and its Go Red For Women initiative are working to fight this widespread, often misunderstood disease with education and research — including battling the misconception that the disease primarily affects men. This year marked the 10th anniversary of the American Heart Association’s National Wear Red Day, which encourages people to wear red the first Friday in February to increase awareness about heart disease among women. Odle’s in-depth look at this subject explores why cardiovascular disease is such a different disease in women than in men and the multitude of issues surrounding its diagnosis and management. Medical imaging continues to play a critical role in this ongoing topic of discussion.

Beyond the Directed Readings, this issue of Radiologic Technology will help you stay informed about original research in the field, with peer-reviewed articles that cover issues you encounter on the job and in the classroom, from methods for decreasing radiation exposure to pediatric patients to a study about online course delivery methods for students in the radiologic sciences. As a 1957 issue of The X-ray Technician (as Radiologic Technology was called at the time) pointed out, “A student today will be a registered technician tomorrow.” You can read more from that 1957 article on the Backscatter page at the end of this issue.

Like the start of a new calendar in January, September also signifies change, even if your school days are long behind you. This September/October issue is the first issue of Radiologic Technology’s 85th volume year. It also marks my first issue as managing editor of the Journal. The rest of the Journal staff and I look forward to bringing you a new volume filled with the information you need to grow within your profession, to stay on the cutting edge of research in your field, and to keep in touch with issues that are important to you as a member of the radiologic science community.

Here’s to a fresh start and a new year.

Alicia Kellogg, MA, has 10 years of publication editing experience and now serves as managing editor of Radiologic Technology.
Decreasing Radiation Exposure on Pediatric Portable Chest Radiographs

Nancy G Hawking, EdD, R.T.(R)
Ted D Sharp, BSIS, R.T.(R)

Purpose To determine whether additional shielding designed for pediatric patients during portable chest exams that ascertain endotracheal tube placement would significantly decrease the amount of scatter radiation.

Methods Children aged 24 months or younger were intubated and received daily morning chest radiographs to determine endotracheal tube placement.

Results For each measurement, the amount of scatter radiation decreased by more than 20% from a nonshielded exposure to a shielded exposure.

Discussion There was a significant decrease in scatter radiation when using the lead shielding device along with appropriate collimation vs appropriate collimation alone.

Conclusion These results suggest that applying additional shielding to appropriately collimated chest radiographs could significantly reduce scatter radiation and therefore the overall dose to young children.

In the first few weeks of infancy, growth and development of organs, tissues, and collective body systems are rapid. The law of Bergonié and Tribondeau states that cellular radiosensitivity is determined by the cell’s mitotic activity. This means that these new cells, which are multiplying and dividing at a rapid rate, are highly sensitive to radiation. In diagnostic radiology, the linear, nonthreshold dose response curve associated with late effects is the primary concern. The probability of radiation-induced cancer and genetic effects increases proportionally with the dose.

In today’s pediatric clinical settings, infants who must be intubated often are radiographed every morning to determine endotracheal tube placement. For infants already highly sensitive to radiation, daily exposure to ionizing radiation increases the possibility of adverse late effects, including developing leukemia or other types of cancer. However, the physicians must consider the risk vs the benefit when ordering chest radiographs on these patients. Because the placement of the endotracheal tube is critical for proper breathing, the benefit of the chest radiographs outweighs the risk associated with the radiation exposure. The necessity of the daily chest radiographs in these circumstances raises the question, “How can the radiation dose to these infants be reduced while continuing daily chest radiographs?” Although there are no “safe limits” of radiation, any amount of reduction is beneficial.

Literature Review

The harmful effects of exposure to ionizing radiation have been studied extensively. Ionizing radiation is a human carcinogen and is cumulative in nature. Many studies examined the biological effects on humans following a radioactive accident or nuclear disaster. Other studies followed patients exposed to large amounts of radiation as a treatment for disease. Most of the subjects in these studies had received high doses of radiation and exhibited more pronounced effects. Although studies of high-dose radiation exposures are essential for understanding overall biological consequences, low-dose long-term health effects are of greater concern to the general public.

Effects of radiation exposures at lower doses are difficult to quantify. Risk associated with low-dose
radiation exposure is derived from linear extrapolations of high-dose responses. Because this formula “is supported by experimentally grounded, quantifiable, biophysical arguments, a linear extrapolation of cancer risk from intermediate to very low doses currently appears to be the most appropriate methodology” to predict the risks of low-dose radiation. According to Brenner and Sachs:

The linear, no-threshold (LNT) approach to estimate such risks involves using epidemiological data at higher (but still low) doses to establish an ‘anchor point,’ and then extrapolating the excess cancer risk linearly down from this point to the low dose of interest.

Studies on increased cancer risk associated with radiation exposure have included breast cancer, leukemia, skin cancer, and thyroid cancer as well as physiological and developmental abnormalities as a result of prenatal and neonatal exposure.

A comparative study on breast cancer included 3 cohorts of women exposed to ionizing radiation:

- Survivors of Hiroshima and Nagasaki.
- Patients in a Massachusetts tuberculosis sanatorium exposed to multiple chest fluoroscopies.
- Patients treated by x-rays for acute postpartum mastitis in New York.

According to the study’s researchers:

Parallel analyses by radiation dose and age at exposure, and time after exposure suggested that risk of radiation-induced cancer increased approximately linearly with increasing dose and was heavily dependent upon age at exposure.

Other studies have found positive correlations between multiple chest radiographs and an increase in breast cancer. Ronckers et al summarized the current epidemiological evidence, stating that:

Data support a linear dose-response relationship down to doses as low as about 100 mSv. However, the magnitude of risk per unit dose depends strongly on when radiation exposures occur: exposure before the age of 20 years carries the greatest risk.

How much more risk would be associated with ages birth to 24 months?

A systematic review of prenatal and postnatal studies between 1990 and 2006 on the effects of diagnostic radiographs as a factor for childhood cancer found a significant increase in leukemia. The researchers suggest their results support earlier evidence that risk increases with radiation exposure. Don raises another concern about the increase in dose to patients with the advent of computed radiography (CR) and direct radiography systems. He suggests that dose to the patient from CR is higher than with film-screen radiography and that overexposure is quite common:

Exposure reduction is important in CR as research indicates an increased risk of childhood acute lymphocytic leukemia from plain-film studies and an increased risk of fatal breast cancer from scoliosis series.

Damaged DNA primarily causes the biological effects of radiation. The 3 main concerns in pediatric radiology are: heritable effects, developing embryo and fetus, and carcinogenesis — the most important consequence of low-dose radiation with a risk of about 5% per sievert. Translocation, one type of chromosome damage, is an intermediate biomarker for cancer risk. A study conducted by Bhatti et al investigated translocation chromosome damage in the ionizing radiation dose-response below the level of approximately 50 mGy. According to the researchers, “Chromosome translocation frequency data from three separately conducted occupational studies of ionizing radiation were pooled together.” Their results showed a significant increase in translocation frequencies with increasing dose. They concluded that:

Chromosome damage is associated with low levels of radiation exposure from diagnostic x-ray examinations, including dose scores of approximately 50 mGy and lower, suggesting the possibility of long-term adverse health effects.

Most scientific and regulatory agencies agree that even low doses of ionizing radiation increase the risk of cancer. Because children are much more vulnerable to the adverse effects of radiation than adults, more protection should be applied. With the increased atomic and cellular activity required for organ and
tissue growth in children, the possibility of DNA and molecular damage is greater. Therefore, every effort should be made to minimize radiation exposure in pediatric patients.\textsuperscript{13}

This study explored whether the radiation dose due to scatter radiation to infant patients receiving daily chest radiographs to check endotracheal tube placement would be reduced with the use of a specialized lead shield. The research question was, “In addition to tight collimation, can the use of a pediatric lead shield reduce scatter radiation and reduce patient dose?”

Methods

A research proposal for the study was submitted to the University of Arkansas for Medical Sciences Institutional Review Board (IRB) for consideration after obtaining approval from the Arkansas Children’s Hospital Research Institute and the Radiation Safety Committee at the hospital. The proposal was approved on March 14, 2011. The inclusion criteria for the human subjects were children 24 months or younger in the Arkansas Children’s Hospital pediatric intensive care unit who were intubated and receiving daily chest radiographs to assess endotracheal tube placement.

The intended sample size was 10 subjects; however, there was some difficulty attaining this number of study subjects in the time allotted for the research. The final sample size was 5 subjects fitting the inclusion criteria. The first male subject (M01) was 23 months old and average size, the second male (M02) was 16 months old and average size, and the third male subject (M03) was 3 months old and small for his age. The first female subject (F01) was 5 months old and small for her age, and the second female subject (F02) was 24 months old and average size. Although the sample size was small, it can be defended by the tightly controlled inclusion variables and the precision of the measurement tool.

Using a one-group pretest/post-test experimental design, the study subjects were measured twice for radiation dose on a chest radiograph checking for endotracheal tube placement: once without the specialized pediatric lead shield and once with it. Extraneous factors were avoided by using the same portable radiograph unit and imaging system (GE AMX IV; Milwaukee, Wisconsin) for each exposure.

The dose measurements were obtained using a Geiger-Müller–based device with a Keithley 35080A portable ion chamber (see Figure 1). Prior to beginning this research, as a part of the IRB submission process for the human use study, the IRB Devices Compliance Department reviewed and approved the dosimeter as an accurate instrument for measuring dosages in this type of research. This type of dosimeter is able to record dosages as low as 0.001 mR. The ion chamber of the Keithley 35080A was placed in the exact same location next to the subject’s chest just outside the collimated beam for each exposure to measure scatter radiation. Tight collimation was used with each radiograph. The technical factors and source-to-image distance were recorded for each subject on the first exposure, and identical technical factors and distance were used on the second exposure.

The specialized pediatric shield designed for this research was an approved 0.5 mm lead equivalent vinyl-coated shielding material tailored for use in a novel way (see Figure 2). The shield was cut into 2 sections in the shape of an “L.” Adjustability for the device was accomplished by hook-and-loop strips on the top of one piece and the underside of the other. The
Figure 2. Tailored lead shielding device.
2 halves of each section of the shield were 12 inches long and 11 inches wide at the widest section. On both halves was a 7-inch-by-3-inch arm at the ends, with integrated right and left markers.

Initial testing of the shield was conducted on skull and knee radiographic phantoms used by resident physicians at the hospital. The testing procedures for the phantoms were identical to those used for the study subjects.

### Analysis
The pre- and postshielding measurements were analyzed to determine the amount of change in scatter radiation per phantom and the mean for each sample group. For this study, the \( \frac{y - x}{x} \times 100 = \% \) of change, where the scatter radiation dose without the shield is represented by the variable \( x \), and the scatter radiation dose with the shield is represented by the variable \( y \). The scatter radiation mean without the shield was calculated by dividing the scatter radiation total (\( \frac{\text{total without shield}}{\text{number of exposures}} \)) by the total number of exposures. The mean percentage of scatter radiation change was determined by using the following equation:

\[
\frac{(\mu_x - \mu_y)}{\mu_x} \times 100 = \% \text{ of change}.
\]

where the mean scatter radiation without shielding is represented by \( \mu_x \), and the mean scatter radiation with shielding is represented by \( \mu_y \).

### Results
The amount of scatter radiation for each phantom and study subject, with and without the special pediatric shielding, was recorded, and the percent change was determined. For each measurement, the amount of scatter radiation decreased by more than 20% from a nonshielded exposure to a shielded exposure (see Table 1). The greatest decrease in percentage from the nonshielded phantom to the shielded phantom was on the skull phantom. A 100% decrease in scatter radiation was also observed.

### Table 1

<table>
<thead>
<tr>
<th>Scatter Radiation</th>
<th>Phantom Device</th>
<th>Scatter Radiation Without Shield (mR)</th>
<th>Scatter Radiation With Shield (mR)</th>
<th>% Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skull phantom</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.172</td>
<td>0.000</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.155</td>
<td>0.000</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.153</td>
<td>0.000</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.161</td>
<td>0.000</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.158</td>
<td>0.000</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Mean dose per phantom</td>
<td>0.160</td>
<td>0.000</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Total (skull phantom)</strong></td>
<td>0.799</td>
<td>0.000</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>Knee phantom</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0.199</td>
<td>0.065</td>
<td>67.3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.192</td>
<td>0.065</td>
<td>66.1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.194</td>
<td>0.056</td>
<td>77.1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.193</td>
<td>0.061</td>
<td>68.4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.193</td>
<td>0.065</td>
<td>66.3</td>
<td></td>
</tr>
<tr>
<td>Mean dose per phantom</td>
<td>0.194</td>
<td>0.062</td>
<td>69.04</td>
<td></td>
</tr>
<tr>
<td><strong>Total (knee phantom)</strong></td>
<td>0.971</td>
<td>0.312</td>
<td>67.9</td>
<td></td>
</tr>
<tr>
<td><strong>Total sample</strong></td>
<td>1.77</td>
<td>0.312</td>
<td>82.4</td>
<td></td>
</tr>
</tbody>
</table>
recorded for each of the 5 exposures with a shield and a mean of 0.000 mR. The mean scatter radiation for the skull phantom without the shield was 0.160 mR. The mean scatter radiation for the knee phantom without the shield was 0.194 mR. The mean scatter radiation for the knee with the shield was 0.062 mR. The mean decrease in scatter radiation from nonshielded to shielded exposures for the knee was 69.04%.

Four of the 5 sets of measurements on the study subjects showed a decrease in scatter radiation of more than 79% from a nonshielded exposure to a shielded exposure (see Table 2). The greatest decrease in scatter radiation from a nonshielded exposure to a shielded exposure was on study subject F02 (96.29%). The decreased scatter radiation mean for both female subjects was 96.02%. The smallest amount of decrease in scatter radiation was from study subject M03 (5.57%). The mean decrease in scatter radiation from nonshielded to shielded exposures was 80.54% for the 3 male subjects. The scatter radiation mean for all 5 study subjects for nonshielded exposures was 17.772 mR, and the mean for shielded exposures was 2.229 mR. The total reduction in scatter radiation for all study subjects from nonshielded to shielded exposures was $\mu = 87.45\%$.

### Discussion

The results of this study suggest that using lead or lead-equivalent shielding material tailored for use on infants receiving daily chest radiographs to evaluate endotracheal tube placement reduced radiation to anatomy not of interest to the examination. Exposures to each phantom and study subject were significantly less when external shielding was used in addition to tight collimation. The most pronounced reduction was with the skull phantom. After careful consideration, it was determined that the pliable nature and unique fit of the

<table>
<thead>
<tr>
<th>Study Subject</th>
<th>Age (months)</th>
<th>Weight</th>
<th>Scatter Radiation Without Shield (mR)</th>
<th>Scatter Radiation With Shield (mR)</th>
<th>% Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>M01</td>
<td>23</td>
<td>Average</td>
<td>6.43</td>
<td>0.820</td>
<td>87.24</td>
</tr>
<tr>
<td>M02</td>
<td>16</td>
<td>Average</td>
<td>2.89</td>
<td>0.603</td>
<td>79.13</td>
</tr>
<tr>
<td>M03</td>
<td>3</td>
<td>Below average</td>
<td>0.520</td>
<td>0.491</td>
<td>5.57</td>
</tr>
<tr>
<td>Total males</td>
<td></td>
<td></td>
<td>9.84</td>
<td>1.914</td>
<td>80.54</td>
</tr>
<tr>
<td>F01</td>
<td>5</td>
<td>Below average</td>
<td>0.562</td>
<td>0.042</td>
<td>92.52</td>
</tr>
<tr>
<td>F02</td>
<td>24</td>
<td>Average</td>
<td>7.37</td>
<td>0.273</td>
<td>96.29</td>
</tr>
<tr>
<td>Total females</td>
<td></td>
<td></td>
<td>7.932</td>
<td>0.315</td>
<td>96.02</td>
</tr>
<tr>
<td>Total sample</td>
<td></td>
<td></td>
<td>17.772</td>
<td>2.229</td>
<td>87.45</td>
</tr>
</tbody>
</table>
shield to the skull phantom prevented scatter radiation better than the shield’s fit to the knee phantom. Figures 3 and 4 emphasize this conclusion.

All but 1 of the study subjects had at least a 79% reduction in scatter radiation when the additional shielding was used. The researchers can only speculate on why M03 did not show the same degree of decrease. It is possible that the ion chamber shifted when the shield was applied or the subject moved slightly (very likely based on the subject’s age), opening a gap between the patient and shield.

These results show that a marked decrease in radiation exposure to anatomy of no interest in a routine radiograph can be achieved with additional radiation protection or shielding even when using tight collimation. Considering that there is no “safe limit” to radiation exposure, the results of this study support the use of a lead shield designed to cover the maximum area of an infant’s body not of interest in the chest radiograph, due both to its efficacy demonstrated by this research study and to appropriate collimation.

Conclusion

Based on these results, the researchers can conclude that shielding and collimation together are the best protection against scatter radiation for all patients, but special consideration should be given for the ones most vulnerable: small children, older or health-infirmed adults, and pregnant women.

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References


E-tutorial Improves Students’ Ability to Detect Lesions

BaoLin Pauline Soh, BAppSc (Hons)  Ann Poulos, PhD
Warren Michael Reed, PhD  Patrick C Brennan, PhD

Purpose  This Australian study explores the effects of an educational intervention on first-year medical radiation sciences (MRS) students by examining eye-tracking metrics while they attempted to detect breast lesions on radiologic images before and after an e-learning tutorial. The study also analyzes performance using receiver operating characteristic methodology.

Methods  Fourteen first-year MRS students were equally and randomly assigned to a control or experiment group to participate in 2 image-detection sessions. The experiment group completed an online e-learning tutorial between sessions. Eighty mammographic breast images from 20 cases were obtained from a validated online image bank. Of those 20 cases, 30% were normal and 70% demonstrated a single-lesion abnormality.

Results  The experiment group demonstrated a 45% increase in the mean number of fixations per case (P = .047), with a 30% increase in sensitivity (P = .022) following the tutorial. The experiment group also demonstrated improved lesion detection overall and a 49% decrease in mean time to first fixation on the lesion (P = .016).

Discussion  This study demonstrates that increased lesion detection is possible after a brief e-learning tutorial. Early changes in the viewing patterns of less-experienced technologists are intriguing, and explanation may be gained from our current understanding of radiologic perception and cognitive neuroscience. The task for the first-year MRS students in this study was only to positively detect a lesion, and we recognize that a higher level of visual processing would be required to critique image quality. Exposure to the brief tutorial, however, might have triggered some learning-related neural changes at an early level of visual processing, representing stimuli relating to task performance.

Conclusion  Participants in the experiment group improved their ability to identify breast lesions, which coincided with changes in eye position metrics and error type analysis. The data presented here suggest that the intervention resulted in a significant improvement in detection by the experiment group.

The effectiveness of any radiological procedure to detect abnormalities relies on a reader’s ability to interpret the medical images accurately. The importance of accuracy in interpretation has led to reader performance research and observer eye position analysis in image interpretation.

Investigating visual search methodologies can lead to a greater understanding of the process of medical image interpretation. Previous studies have shown distinct differences in visual search strategies between experienced (expert) and less experienced (naive) readers. Experienced readers tend to fixate on the lesion location almost immediately after the images are displayed, search the image in a continuous sweeping-eye motion, have fewer fixations, and spend less time searching the entire image than less-experienced readers.

A vast range of studies have used eye position analysis to investigate different aspects of psychological phenomena, autism, and issues related to learning. Similarly, visual search strategies often are investigated using an eye tracker device that records eye movement. These eye-tracking systems use an infrared camera to generate a corneal reflection, which, in turn, produces the bright pupil effect that determines the eye gaze.
E-tutorial Improves Students’ Ability to Detect Lesions

This study investigates the effect of a basic educational tool on first-year medical radiation sciences (MRS) students’ search strategies and ability to detect breast lesions. The information yielded could improve our understanding of the differences between naïve and expert observers and provide a better appreciation of how quickly expert search strategies can be developed.

Materials and Methods

This study measured the performance and eye position of first-year MRS students detecting breast lesions in mammographic images before and after an e-learning tutorial. The students were randomly assigned to a control or experiment group and performed 2 lesion detection sessions. Only the students from the experiment group participated in the e-learning tutorial. Relevant institutional review board approval was obtained for this study.

Observer Groups

Fourteen first-year MRS students participated in this study and were randomly assigned to either a control or an experiment group (7 per group). The students had a rudimentary radiation science education but no clinical experience or mammographic education.

The entire procedure consisted of 3 stages:

- **Stage 1** involved lesion detection and eye-tracking session No. 1.
- **Stage 2** was participation in an e-learning tutorial.
- **Stage 3** involved lesion detection and eye-tracking session No. 2.

Both groups participated in stages 1 and 3, but only the experiment group participated in stage 2. The second lesion detection and eye-tracking session (stage 3) was held 1 week after the experiment group had completed the e-learning tutorial, which was introduced 1 week after the stage 1 lesion detection and eye-tracking session.

The students were not aware of the specific aims of the study, and those from the experiment group were asked not to discuss or reveal details of the Web-based tutorial with the control group. Participants received no feedback until the study was completed.

E-learning Tutorial

The Web-based tutorial focused on female breast anatomy, image positioning, mammogram viewing, mammogram analysis, mammographic appearance of the normal breast, and mammographic interpretation.

The ROC methodology is used in observer performance studies to assess accuracy and observer performance in terms of sensitivity, specificity, and confidence ratings. The ROC curve is a graphical plot of the 1-specificity (x-axis) vs sensitivity (y-axis) or a graphical plot of the false-positive rate (x-axis) vs true-positive rate (y-axis).
breast, and appearances of asymmetric density and masses. The tutorial took, on average, 1 hour to complete.

**Film Test Banks**

Eighty breast images from 20 cases were presented in random order using ClearView software 2.7.1 (Tobii Technology, Danderyd, Sweden). Of those images, 30% (6 cases) were normal, and 70% (14 cases) demonstrated a single-lesion abnormality of varying subtlety. The images were obtained from a validated online image bank from the McGill Faculty of Medicine. Cranio-caudal and mediolateral oblique images of both left and right breasts were presented for each case.

**Viewing Conditions**

Images were presented on a Hewlett-Packard 1740 monitor (Hewlett-Packard Development Company LP, Palo Alto, California), with a screen resolution of 1280 × 1024 pixels using a Quadro FX 560 graphics card (NVIDIA Corporation, Santa Clara, California) and 24-bit color scale. The viewing distance of the observer to the display monitor was approximately 60 cm. Because the eye-tracking mechanisms were sensitive to near-infrared light, and to standardize the viewing conditions, viewing took place in a room without windows, with ambient lighting fixed at 100 lux.

**Eye-Tracking Metrics**

A single computer with a dual-head graphics card and a double-screen configuration was used, with 1 screen to display mammographic images and another to enable the researcher to ensure optimal eye-tracking data. Eye-position data was recorded using the Tobii X50 (Tobii Technology, Danderyd, Sweden) remote eye-tracking system set at the following configurations: screen width of 34 cm; screen height of 27 cm; distance of the eye tracker from the screen, 1.5 cm; and the angle between the eye tracker and screen at 59° (see Figure 1).

Before sessions took place, a 5-point calibration procedure was carried out for each student participant. All data recorded during the eye-tracking procedure were processed through ClearView software. The software measured:

- Mean time taken to first fixation on the lesion.
- Mean fixation duration on lesion.
- Mean number of fixations per case.
- Mean total time taken to scrutinize each mammographic case.

Fixation had occurred when the mean horizontal and vertical eye position coordinates, measured for a minimum temporal threshold of 100 milliseconds, did not move more than a spatial threshold of 1° of visual angle.

An analysis of improvement was performed, in addition to measuring the parameters above, to compare and contrast the various eye position metrics of only those images where a lesion was detected in the second viewing but had been missed in the first.

An error analysis allocated each unreported lesion to 1 of the following 3 groups:

- Visual search error – missed lesions that were never fixated upon.
- Pattern recognition error – missed lesions that were fixated upon for fewer than 1000 milliseconds but were not detected or recognized.
Nonsignificant increases were noted in the other eye-position parameters within the experiment group following the tutorial intervention. No differences were noted for the control group.

**Observer Performance**

AUC values, sensitivity, and specificity results are shown in Table 3 and Table 4. The data show a significant decrease for the control group ($P = .03$) and an increase ($P = .022$) for the experiment group in sensitivity with the second viewing compared with the first. No other changes were noted.

**Error Analysis**

In the experiment group, the order of error frequency for the first viewing was similar to that of the control group, with decision-making the most common error (see Figures 2 and 3). The order of the frequency of error type for the second viewing, however, changed for the experiment group; the visual search error became more common than the pattern recognition error, and the decision-making error remained the most common.

**Discussion**

This study demonstrates for the first time that increased lesion detection can follow a brief e-learning tutorial, which might represent the early stages of a rudimentary transition from naive to expert reader behavior. In addition, the frequency of error types for the experiment group that are evident only in the second viewing is similar to those demonstrated by expert readers. Accepting that experts’ viewing patterns are developed to a higher level after years of learning and experience, these early changes in naive observer viewing patterns are intriguing, and explanation should be sought from our current understanding of radiologic perception and cognitive neuroscience.

An important aspect of image assessment is the detection of abnormalities and subsequent diagnosis, which requires in-depth medical knowledge. It should be recognized that the task given to the first-year MRS students in this study was only to positively detect a lesion. A higher level of visual processing would be required for the interpretation stage completed by a radiologist.

It has been discussed elsewhere that the earliest development of visual skills occurs at the initial stages of
### Table 1

**Eye Position Metrics in Control and Experiment Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage</th>
<th>Mean Time to First Fixation on Lesion (ms)</th>
<th>Mean Fixation Duration on Lesion (ms)</th>
<th>Mean No. of Fixations per Case</th>
<th>Mean Total Duration of Image Scrutiny per Case (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>First reading</td>
<td>2258 SD:1137</td>
<td>646 SD:233</td>
<td>40 SD:14</td>
<td>12280 SD:6303</td>
</tr>
<tr>
<td></td>
<td>Second reading</td>
<td>2567 SD:2608</td>
<td>706 SD:269</td>
<td>26 SD:15</td>
<td>10348 SD:53324</td>
</tr>
<tr>
<td>P value</td>
<td>.813</td>
<td>.10</td>
<td>.30</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>First reading</td>
<td>3442 SD:2357</td>
<td>778 SD:365</td>
<td>44* SD:29</td>
<td>17819 SD:9219</td>
</tr>
<tr>
<td></td>
<td>Second reading</td>
<td>4968 SD:3510</td>
<td>1034 SD:260</td>
<td>64* SD:30</td>
<td>28017 SD:12205</td>
</tr>
<tr>
<td>P value</td>
<td>.81</td>
<td>.22</td>
<td>.047*</td>
<td>.109</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviation:** SD, standard deviation.

*Asterisk (*) indicates a significant change.

### Table 2

**Eye Position Metrics for Lesions Detected in Second Reading but Missed in First Reading**

<table>
<thead>
<tr>
<th>Group</th>
<th>Stage</th>
<th>Mean Time to First Fixation on Lesion (ms)</th>
<th>Mean Fixation Duration on Lesion (ms)</th>
<th>Mean No. of Fixations per Case</th>
<th>Mean Total Duration of Image Scrutiny per Case (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>First reading</td>
<td>4508 SD:4735</td>
<td>702 SD:385</td>
<td>29 SD:18</td>
<td>9887 SD:8972</td>
</tr>
<tr>
<td></td>
<td>Second reading</td>
<td>3217 SD:2449</td>
<td>774 SD:140</td>
<td>33 SD:14</td>
<td>11407 SD:6244</td>
</tr>
<tr>
<td>P value</td>
<td>.313</td>
<td>.01</td>
<td>.685</td>
<td>.44</td>
<td></td>
</tr>
<tr>
<td>Experiment</td>
<td>First reading</td>
<td>4767* SD:624</td>
<td>776 SD:171</td>
<td>48 SD:8</td>
<td>18088 SD:2846</td>
</tr>
<tr>
<td></td>
<td>Second reading</td>
<td>2412* SD:1237</td>
<td>798 SD:229</td>
<td>53 SD:26</td>
<td>32542 SD:11769</td>
</tr>
<tr>
<td>P value</td>
<td>.016*</td>
<td>.375</td>
<td>.108</td>
<td>.078</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviation:** SD, standard deviation.

*Asterisk (*) indicates a significant change.*
### Table 3

**Area Under Curve, Sensitivity, and Specificity Results for Control Group**

<table>
<thead>
<tr>
<th>Reader Integral</th>
<th>AUC First Reading</th>
<th>AUC Second Reading</th>
<th>Sensitivity First Reading</th>
<th>Sensitivity Second Reading</th>
<th>Specificity First Reading</th>
<th>Specificity Second Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.677</td>
<td>1.000</td>
<td>0.643</td>
<td>0.500</td>
<td>0.667</td>
<td>1.000</td>
</tr>
<tr>
<td>2</td>
<td>0.847</td>
<td>0.707</td>
<td>0.714</td>
<td>0.571</td>
<td>0.833</td>
<td>0.833</td>
</tr>
<tr>
<td>3</td>
<td>1.000</td>
<td>1.000</td>
<td>0.429</td>
<td>0.429</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>4</td>
<td>0.688</td>
<td>0.754</td>
<td>0.286</td>
<td>0.143</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>5</td>
<td>0.857</td>
<td>0.712</td>
<td>1.000</td>
<td>0.857</td>
<td>0.167</td>
<td>0.167</td>
</tr>
<tr>
<td>6</td>
<td>0.800</td>
<td>0.889</td>
<td>0.643</td>
<td>0.286</td>
<td>0.667</td>
<td>0.833</td>
</tr>
<tr>
<td>7</td>
<td>0.826</td>
<td>1.000</td>
<td>0.786</td>
<td>0.500</td>
<td>0.833</td>
<td>1.000</td>
</tr>
<tr>
<td>Treatment means/median</td>
<td>0.814, 0.915</td>
<td>0.866, 0.995</td>
<td>0.643, SD:0.233, 0.500, SD:0.225</td>
<td>0.833, SD:0.286, SD:0.304</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>.442</td>
<td>.031*</td>
<td>.250</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Treatment means differences | -0.005 | Cl: -0.207, 0.103 |

**Abbreviations:** AUC = area under curve; SD = standard deviation; CI = confidence interval. Asterisk (*) indicates a significant change.

### Table 4

**Area Under Curve, Sensitivity and Specificity Results for Experiment Group**

<table>
<thead>
<tr>
<th>Reader Integral</th>
<th>AUC First Reading</th>
<th>AUC Second Reading</th>
<th>Sensitivity First Reading</th>
<th>Sensitivity Second Reading</th>
<th>Specificity First Reading</th>
<th>Specificity Second Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.597</td>
<td>0.890</td>
<td>0.643</td>
<td>0.786</td>
<td>0.500</td>
<td>0.833</td>
</tr>
<tr>
<td>2</td>
<td>0.833</td>
<td>1.000</td>
<td>0.571</td>
<td>0.786</td>
<td>0.833</td>
<td>1.000</td>
</tr>
<tr>
<td>3</td>
<td>0.874</td>
<td>0.905</td>
<td>0.714</td>
<td>0.857</td>
<td>0.833</td>
<td>0.833</td>
</tr>
<tr>
<td>4</td>
<td>0.959</td>
<td>1.000</td>
<td>0.929</td>
<td>1.000</td>
<td>0.833</td>
<td>0.833</td>
</tr>
<tr>
<td>5</td>
<td>0.847</td>
<td>0.835</td>
<td>0.857</td>
<td>0.929</td>
<td>0.667</td>
<td>0.667</td>
</tr>
<tr>
<td>6</td>
<td>0.959</td>
<td>1.000</td>
<td>0.500</td>
<td>0.929</td>
<td>1.000</td>
<td>1.000</td>
</tr>
<tr>
<td>7</td>
<td>0.976</td>
<td>1.000</td>
<td>0.929</td>
<td>1.000</td>
<td>1.000</td>
<td>0.833</td>
</tr>
<tr>
<td>Treatment means/median</td>
<td>0.863, 0.985</td>
<td>0.947, 1.011</td>
<td>0.714, SD:0.174, 0.929, SD:0.091</td>
<td>0.833, SD:0.178, SD:0.115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>.086</td>
<td>.022*</td>
<td>.586</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Treatment means differences | -0.0084 | Cl: -0.184, 0.016 |

**Abbreviations:** AUC = area under curve; SD = standard deviation; CI = confidence interval. Asterisk (*) indicates a significant change.
learning played an important role in the task they were asked to perform. The students appreciated the detection task, which highlighted the importance of task relevance in inducing changes in the visual processing system.

For observers who were repeatedly presented with 2 identical targets, learning occurred independently and only when the target relevant to the task was emphasized, which is in contrast to when both targets were emphasized as being relevant. These experiments demonstrated the relevance of performance increasing with training in the task required. Therefore, the perceived relevance of the educational tutorial given to naïve observers played a role in the improved performance shown in our study and has clear implications for all educational programs.

Conversely, a significant decrease in sensitivity was

Visual processing in the brain. Limited exposure to a visual task is sufficient to trigger detectable changes in the visual system. To identify regions of pathologic importance, however, requires more highly specialized cognitive knowledge of specific representations to report a malignant mass. The multiple representations of the mass set it apart from benign findings, and a higher level of computational complexity of visual processing is required for this discrimination process. This process relies on both specialized cognitive knowledge for radiologic recognition and consistent exposure to the visual task so that required neuroplastic or synaptic changes occur, thus increasing this specialization of the visual system. These higher-level modifications are unlikely to have occurred within the participants in our study, yet exposure to this brief tutorial might have triggered some learning-related neural changes at an early level of visual processing, representing stimuli relating to task performance.

All participants in this study were students at the beginning of an imaging science course, and the principles and practice of mammographic procedures they were

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**Figure 2.** Percentage of each error type for the experiment group.

**Figure 3.** Percentage of each error type for the control group.
noted in the control group, where no tutorial was given. This decrease could be attributed to students’ lack of motivation because they had no prior knowledge of lesion appearance and therefore no clear understanding of the task’s relevance.

Retention of information with a detection task such as the one described here is worthy of consideration. Although participants in the experiment group viewed only a 1-hour e-learning tutorial, they retained a level of increased performance. It has been discussed elsewhere that 2 processes are related to the acquisition of improved perception: fast learning and slow learning (latent learning phase).\textsuperscript{37} Fast learning, which involves a short and rapid training session, produces improvement in performance that occurs during the very first training session of naive observers.\textsuperscript{37,40}

The fast learning effect quickly saturates, however, which then leads to the slow-learning stage. During this stage, knowledge and visual skills undergo a latent phase in which the learned knowledge and skills are consolidated before a larger performance gain emerges. The knowledge and skills gained through this slower stage can be retained for many years.\textsuperscript{33,35,37,41-43} It is unclear whether the naive observers in our study went through both processes or just the fast-learning stage. Although this question requires further study, the literature states that it is possible that some breast-lesion detection ability could be retained by naive observers.

The results of this study, showing an early stage of training with naive observers, have not been demonstrated before, but these results mirror those achieved elsewhere with longer training periods and a different set of observers. In the Manning et al study, for example, radiographers who underwent a 6-month chest reporting training demonstrated a 17% improvement in detection upon completion of the course.\textsuperscript{2} The level of improvement observed in our experiment group (AUC: from 0.863 to 0.947 = 10%) with the 1-hour e-learning tutorial appears comparable to the 17% improvement reported with the 6-month training program. This result may provide some evidence of the quick saturation that occurs in fast-stage learning and match initial data on the time frame of these types of learning experiences. Further research is required.

The authors acknowledge that the number of cases and observers were relatively small and the conclusions drawn might not directly extrapolate to the larger population. Further, we acknowledge a difference in the abnormality prevalence rate present in the study compared with an actual clinical setting. The higher ratio of abnormal (70%) to normal (30%) images was necessary to demonstrate a comprehensive range of lesion sizes, shapes, and types to the first-year MRS students. Another potential limitation of this study was the use of conventional ROC as opposed to free-response methods.

Future work could perform similar studies with an increased number of naive observers and cases. Because most studies related to performance in image interpretation lack a control group, the inclusion of the control group should be considered. Increasing the duration of the e-learning tutorial to examine possible changes in observer performance also could be included in future research.

**Conclusion**

This study demonstrates that the performance of naive observers in breast-lesion detection improved after a brief e-learning tutorial. The increase in detection sensitivity and improvement could be connected to changes in eye position and was demonstrated by a significant increase ($P = .047$) in the mean number of fixations per case and a change in the proportion of error types. The analysis of improvement showed a significant decrease ($P = .016$) in the mean time to first fixation on the lesion. This work appears to show that naive observers who complete a brief e-learning tutorial exhibit expert characteristics in detection afterward, although in a limited and rudimentary manner.

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Ann Poulos, PhD, is an adjunct associate professor and a member of MIOPeG in the discipline of MRS at the University of Sydney-Faculty of Health Sciences.
References


E-tutorial Improves Students’ Ability to Detect Lesions


Online Course Delivery Modes and Design Methods in the Radiologic Sciences

Nina Kowalczyk, PhD, R.T.(R)(CT)(QM), FASRT  
Stacey Copley, MS, BSNM

Purpose  To determine the current status of online education in the radiologic sciences and to explore learning management systems, course design methods, and online educational tools used in the radiologic sciences.

Methods  A random sample of 373 educators from Joint Review Committee–accredited radiography, radiation therapy, and nuclear medicine technology educational programs was invited to participate in this study with an online survey.

Results  The majority of the programs responding to the survey do not offer online core courses. However, the institutions that do provide online core radiologic courses reported limited use of online tools for course delivery. BlackBoard was reported as the most commonly used learning management system. No significant relationships were identified in reference to self-reported instructor information technology self-efficacy and the instructors’ age, years of teaching in higher education, years of teaching online, or use of asynchronous and synchronous technologies. Survey results did demonstrate a significant relationship between the type of institution and the use of synchronous technologies, suggesting that university-based programs were more likely to use this technology.

Discussion  Although the results suggest that online distance education is still not prevalent in radiologic science education, the past 3 years have seen a substantial increase in online course activity. This increase emphasizes the importance of adequate educator instruction and continuing education in the use of interactive technologies for online content delivery. Most educators report receiving 1 to 4 hours of training prior to online course implementation, but additional postimplementation training is necessary to improve the success of online delivery and further integrate interactive learning activities into an online format.

Conclusion  The traditional classroom setting is still the primary course offering for radiologic science programs. PowerPoint remains the primary content delivery tool, suggesting a need for educators to incorporate tools that promote student interactions and interactive learning. Although the results did not reveal a significant relationship between assessed factors, the small correlations identified suggest that the younger instructors have a higher information technology self-efficacy. In addition, survey results suggest that instructors responding to this survey received limited training in reference to online course methods and design both before and after implementing an online course. Although educators may not have a choice regarding the system adopted by their university or college, they should seek additional training regarding the best tools available for online course delivery methods.

Distance education is not a new phenomenon, but one form of it — online education — is a growing trend, especially in higher education, due in part to greater accessibility to the Internet and computers. According to a 2009 Sloan Consortium survey, approximately 5.6 million students were taking at least one online course, compared to 2.35 million students taking online courses in 2004.1,2 Although student success and satisfaction is a key factor in distance education, it is also important to evaluate how educators are adapting to this shift to electronic course design and delivery. While online learning is gaining popularity within higher education institutions, radiologic science programs have not widely adopted it. In fact, a 2009 report from the Joint Review Committee on Education in Radiologic Technology (JRCERT) indicated that of the 729 accredited programs in radiography, radiation therapy, medical dosimetry, and
magnetic resonance imaging, 48 programs (7.2%) offer distance education. Previous research often focused on the educational technology, student needs and perceptions, and theoretical guides for consideration when designing online classes. However, little is known about the current use of online learning in the radiation sciences and how radiologic science educators are adapting to this new teaching environment. This is a concern because the use of online resources as a primary source of learning or in conjunction with traditional educational methods has been shown to enhance student learning and encourage self-directed learning. When employed to the fullest potential, a learning management system (LMS) provides a platform on which to build richly collaborative communities of learning around a particular subject matter.

Literature Review

The literature search yielded few studies regarding distance learning or online instruction in the radiologic sciences, suggesting a need to re-explore this topic. However, adult education literature regarding online methods of collaborative learning in an online environment is relevant to all educators, regardless of the academic discipline. The role of the facilitator is critical to successful online course instruction. Instructors must adopt interactive teaching styles to encourage independent and collaborative learning, allowing knowledge to be gained through interaction between fellow students and the instructor. This change requires a shift in radiologic science educators’ traditional educational practices. The diffusion of innovation theory addresses the concept of adopting innovative change to a specific group. This theory could be helpful in identifying the current state of online course delivery modes and design methods in radiologic science education and provide insight into the steps necessary for the successful adoption of online course delivery.

Online Education in the Radiologic Sciences

In 1996, Cauble and Chernow examined distance learning in the radiologic sciences. Results of their study suggested communication between faculty members and between students and faculty needed improvement. Concerns also were raised about the appropriate use of technology. Although technology has changed over the past 17 years, the use of appropriate educational technology must be managed for program success. Students must have clear instructions and expectations regarding course requirements. This requires constant communication between the instructor and the students.

In 2006, Britt surveyed radiologic technology students, nursing students, and the faculty of these programs to explore perspectives regarding online learning. Results indicated a pattern of advantages and disadvantages of the online learning environment consistent with previous research. Faculty expressed concern regarding lack of preparation time, lack of student contact, and unfamiliarity with the technology. Interestingly, one-third of the faculty members responding to the survey had no training in the technology prior to initiating an online course. Thus, many instructors expressed discomfort in teaching in an online environment. In addition, most of the instructors were educated by and familiar with traditional face-to-face lectures and are therefore most comfortable with that educational approach. Faculty also expressed that online course preparation is labor-intensive. Although Britt indicated that additional research is needed to evaluate student and faculty perceptions as individuals become more accustomed to online learning, no recent studies are investigating this topic.

Johnston assessed the instructional effectiveness of online radiography course instruction in his study comparing outcomes in patient care and radiation protection when radiography students participated in traditional face-to-face vs online courses. Student outcomes were evaluated using a t test and analysis of variance (ANOVA) to determine whether the variance in grade point average and American Registry of Radiologic Technologists exam scores among the student populations was significant. Although the grade point average difference was not statistically significant, the Registry examination scores indicated that students who attended face-to-face classes performed significantly better than students who attended online classes. Johnston concluded that the effectiveness of online instruction should continue to be evaluated in different disciplines and in reference to a larger
variety of course content. Emphasis also was placed on the need to alter teaching methods in an online environment. The Registry score comparison results suggest that instructors should design engaging self-learning activities for their students.\textsuperscript{8}

**Collaborative Course Design**

Collaborative learning theory postulates that students are responsible for building on their own knowledge, and instructors are responsible for facilitating the learning processes instead of serving as the primary focus of learning.\textsuperscript{9} Collaborative learning in the classroom or in an online learning environment requires a change in our content delivery methods from instructor-centered methods to delivery methods that develop and encourage self-directed learning. Thus, in the role of facilitator, the instructor must relinquish some control of the learning — a difficult shift for many educators, especially if they were not educated in a collaborative manner. The facilitator acts as an observer and a resource while the students work through the learning process independently and in groups. Instead of being the leader, the facilitator is an equal participant of the group. This course delivery shift is crucial to ensure radiologic science graduates have the skills required to seek answers to challenges they may face in the imaging environment and to be self-directed learners throughout their careers.

Because Web technology supports collaborative learning processes, an online learning environment offers educators the ability to create a collaborative environment if online instructional models are designed to facilitate student-centered learning experiences properly.\textsuperscript{9,10} An LMS not only provides a medium for instructors to create a course infrastructure, but it also offers the opportunity for multimode instruction such as visual-, audio-, and text-based learning prompts. Interactive online discussion, coaching, collaboration, reflection, and self-regulated learning also are great tools offered by many LMS platforms.\textsuperscript{11} Student involvement is essential to the learning activity, and a collaborative learning model can be used in either a synchronous or an asynchronous method of delivery to allow the learners to interact with one another to accomplish a task.\textsuperscript{9} However, these learning strategies are effective only if the educator has a positive attitude regarding online education and demonstrates a willingness to adapt to an online learning environment. For this arrangement to be successful, the educator must adopt the role of facilitator, thus allowing the students to create meaning from the online learning experience.

As a facilitator, instructors must consider the factors that play a role in course design: adult learning models, maximizing the use of technology provided, and maintaining an open-mindedness about the change in instructor role. Three instructor factors that greatly affect the success of online learning are information technology (IT) competency, teaching style, and attitude.\textsuperscript{12} Information technology competency and attitude share a relationship in that competency sometimes influences instructors’ attitude toward the use of technology for online courses. Teaching style also relates to attitude, as educators may need to change or alter their teaching style to effectively present content and facilitate learning in an online course.

For radiologic science programs and educators to make a successful transformation to the online learning environment, emphasis must be placed on the use of appropriate adult learning models, instructor competency, and information literacy regarding the chosen content delivery technology. The willingness of instructors to adapt their teaching style to collaborative learning is crucial for successful implementation of online learning environments.

It is common for educators to use the instructional approach they believe is most appropriate for the content covered; however, it is important that they be cognizant of current literature questioning traditional educational methods.\textsuperscript{13} Instructors need to present a collaborative and interactive teaching style encouraging communication and interaction between fellow students and the instructor.\textsuperscript{14} This is especially important when using asynchronous technologies.

**Diffusion of Innovation Theory**

In 1983, Everett Rogers postulated the Diffusion of Innovation theory to describe the adoption, implementation, and assimilation of new advances.\textsuperscript{15} The theory has been used to research new technological innovations across different sectors of business and industry, especially complex trends in agriculture and health. Rogers described diffusion as the process by which
an innovation is communicated within members of a specific social system (eg, radiologic educators). It is a social process by which new ideas are communicated from an individual who understands a specific innovation to an individual who knows nothing about the innovation. The term “innovation” refers to a practice that is new to an adopting group but not necessarily a new practice. Diffusion of innovation identifies 5 specific steps involved in the decision process: knowledge, persuasion, decision, implementation, and confirmation. The theory also classifies individuals as innovators, early adopters, late adopters, and laggards, based upon the speed at which they adopt an innovation. This theory is useful in understanding the importance of a cohesive community of radiologic educators. It also emphasizes the need for innovators and early adopters to share their knowledge and experiences to help our “community of practice” move toward the use of collaborative online course delivery tools and models.

Study Objectives
A Web-based exploratory survey provided a descriptive analysis of the status of online education in the radiologic sciences in reference to course delivery, design, and resources. This research study was determined to be exempt by The Ohio State University Institutional Review Board. The survey sought to answer:
1. What is the status of distance education in the radiologic sciences?
2. What learning management systems commonly are used for online course delivery?
3. What are the common course design methods of content delivery?

Methods
Sample
The names and e-mail addresses of radiologic science program directors were obtained from the JRCERT and Joint Review Committee on Educational Programs in Nuclear Medicine Technology. Duplicates were purged and selection error was controlled. A stratified random selection of programs generated from the list of program directors was determined using the Excel (Microsoft, Redmond, Washington) randomization function to ensure a representative population of programs was included based upon the primary discipline (radiography, radiation therapy, or nuclear medicine) and educational level of the academic programs (baccalaureate, associate, and certificate). Once the randomized programs were selected, individual instructor e-mail contact information was accessed via the academic institutional websites, resulting in a random stratified sample of 373 educators.

Instrumentation
The survey instrument was adapted from a survey titled “Distance Education at Postsecondary Institutions, 2006-07” by the U.S. Department of Education, National Center for Education Statistics, as well as the Motivated Strategies for Learning Questionnaire. Four sections comprise the survey instrument:
- Section 1 explores the status of online education in the radiologic sciences.
- Section 2 determines the percentage of time the instructor uses course delivery technologies and identifies the online LMS and delivery tools used in the online courses.
- Section 3 relates to the instructors’ self-identified IT self-efficacy.
- Section 4 obtains demographic information.
A panel of 4 experts conducted a field test for content validity and face validity of the instrument prior to distribution using SurveyMonkey (Palo Alto, California). Educators received an e-mail describing the research study and providing a link to the SurveyMonkey site. The survey was open for 4 weeks, and a reminder e-mail was sent 2 weeks after the initial invitation.

Data Analysis
All data were collected through SurveyMonkey, and responses were anonymous. Data were transferred to an Excel spreadsheet and statistically analyzed using SPSS.
software (IBM, Chicago, Illinois). The frequencies were reported for sections 1, 2, and 3 of the questionnaire.

Results

Of the 373 electronic survey invitations sent, one was returned as undeliverable, and 7 were rejected by the recipient; the final sample size was 365 individuals. Of these 365 invitees, 102 responded to the survey, resulting in a 27.95% response rate. Of the 102 survey respondents, 38 indicated their institution offers online courses, suggesting that approximately 37% of the educators responding are involved in online course delivery. Of those 38 respondents whose institutions offer online course instruction, 12 surveys were incomplete and not used in the final data analysis. This resulted in a final analysis of sections 2, 3, and 4 based on a sample size of 26 educators.

Sample Demographics

The age of respondents ranged from 21 to 70 years, with the majority aged between 40 and 60 years. Most respondents are educators in radiography (90.0%), followed by nuclear medicine (7.8%) and radiation therapy (2.2%). Most respondents (63%) are employed at a 2-year community or junior college followed by 19% at a 4-year university and 17.9% in a hospital-based program. In reference to the campus structure, 83.3% of respondents are employed on site at a main college or university campus.

The years of teaching experience in higher education ranged from 1 to 40 years, with the majority of respondents having fewer than 20 years of experience. The majority of respondents (52.8%) have never taught an online course. Of those 42 respondents who have taught online courses at some point in their career, 78.6% have been teaching online courses for 5 or fewer years (see Table).

The Status of Distance Education in the Radiologic Sciences

Approximately one-third (37.3%) of the 102 respondents’ institutions had offered online courses for the core curriculum in their radiologic science program in the past 5 years. Of 38 educators who reported experience teaching online courses in the past 5 years, 36.4% stated that they offer fully online courses, whereas 78.8% offer hybrid or blended courses in the core radiologic technology curriculum. Educators

Table

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<tr>
<th>Demographics</th>
<th>Question/Response Options</th>
<th>n (%)</th>
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<tbody>
<tr>
<td>What is your age in years?</td>
<td>21-30</td>
<td>1 (1.1)</td>
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<tr>
<td></td>
<td>31-40</td>
<td>22 (24.4)</td>
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<tr>
<td></td>
<td>41-50</td>
<td>35 (38.9)</td>
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<tr>
<td></td>
<td>51-60</td>
<td>38 (31.1)</td>
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<tr>
<td></td>
<td>61-70</td>
<td>4 (4.4)</td>
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For the courses that you teach, what is your primary radiology concentration?

- Radiography | 81 (90.0)
- Nuclear medicine technology | 7 (7.8)
- Radiation therapy | 2 (2.2)

In what type of educational institution is your radiologic sciences program offered?

- Community or junior college (2 year) | 53 (63)
- University (4 year) | 16 (19)
- Hospital-based (certificate) | 15 (17.9)

What is your campus structure?

- Main campus (on site) | 75 (83.3)
- Satellite campus (on site) | 15 (16.7)
- Distance (online) | 0 (0.0)

Years of teaching experience in higher education

- 1-5 | 14 (15.9)
- 6-10 | 29 (33)
- 11-20 | 18 (20.5)
- 21-30 | 21 (23.9)
- 31-40 | 6 (6.8)

Years of experience teaching online courses

- 0 | 47 (52.8)
- 1-5 | 33 (37.1)
- 6-10 | 7 (79)
- 11-20 | 0 (0.0)
- 21-30 | 2 (2.2)
who reported experience in teaching online courses were asked to report the number of fully online core courses and the number of hybrid or blended core courses within the radiologic sciences program. Five of the 38 educators reporting experience with online education did not complete the entire survey. Fifteen of the 33 respondents reported experience teaching fully online courses with no face-to-face classroom time. In reference to hybrid and blended core courses, 24 of the 33 educators responding (30.3%) have taught a hybrid or blended course, but none of the educators responding to the survey have taught more than 5 hybrid or blended online courses.

The final survey question regarding the status of online education in the radiologic sciences inquired whether the online core course had an equivalent traditional face-to-face course. A majority of the educators' programs (81.8%) do not offer an equivalent traditional face-to-face course.

Commonly Used Learning Management Systems

BlackBoard was the most commonly used LMS, with 53.8% of the respondents using it, followed by 19.2% using Desire to Learn. WebCT and Moodle both had a response of 7.1%, with no respondents identifying the use of Learning Space. Respondents who chose the “other” option wrote in Angel, Google Docs, and CE6.

Common Course Design Methods of Content Delivery

A total of 26 educators responded to this portion of the survey questionnaire. The majority (96.2%) of online educators report that they develop their own online courses specific to course content and delivery. In addition, 30.7% of the respondents report developing the online course content with textbook online resources and materials from licensed commercial vendors of online programs. Very few educators reported collaborating with other postsecondary institutions or using a licensed commercial vendor only when they developed the course content. Only one respondent indicated institutional support in the course delivery design, stating that his or her institution has a “Center of Teaching Excellence” that researches and collaborates to set up the system for the facility.

Educators reported that although they may be required to design the online course, 80.7% received training prior to course implementation. Approximately one-third of the respondents indicated they attended 1 to 4 hours of training prior to the course implementation. Approximately 19% of the respondents received 5 to 10 hours of training, followed by 15.4% of the respondents receiving more than 40 hours of training prior to course implementation. Interestingly, however, fewer than half (42%) of the respondents received additional training regarding online technologies after the online course was implemented. Those who did receive postimplementation training (53.7%) reported attending 1 to 40 hours of training after the online course was implemented. Only one respondent received more than 40 hours of training after the online course was implemented. The majority (26.9%) received 1 to 4 hours of postimplementation course training. The location of the online technologies training was most often an on-site workshop. Furthermore, all of the respondents reported the presence of “institutional IT support,” with 23.1% indicating IT support at the departmental level.

In reference to course design resources and methods of delivery, the respondents were asked to indicate the amount of time they used each of the different technologies in their online courses. From the choices provided, the most frequently used technology was “discussion and message boards.” Approximately 80% of the respondents reported using discussion boards in their online courses; however, this technology is not heavily used as a means of student interaction. Approximately 62% of the respondents reported using asynchronous technologies more than 50% of the time in the online course. “Synchronous” Internet technologies were used less frequently, with 38.5% of the respondents reporting their use in online courses.

From the choices provided, the second most frequently used method of content delivery (65.4%) in their online learning programs was “asynchronous technologies.” However, 30.8% of the respondents reported using asynchronous technologies more than 50% of the time in the online course. “Synchronous” Internet technologies were used less frequently, with 38.5% of the respondents reporting their use in online courses.

Approximately 58% of the educators responding to the survey used “one-way prerecorded video-audio” technologies such as interactive TV, podcasts, and webcasts. However, most who responded to this survey question used the technology 25% of the time.
allotted for the online course. “Two-way interactive video-audio” content delivery systems such as Skype (Skype Communications SARL, Luxembourg City, Luxembourg) or compressed video were used by only 23% of the educators responding to the survey, with 83% of those reporting use of the technology less than 50% of the time allocated for the online course (see Figure).

In addition, blogs and wikis were rarely used in online learning courses (7.7% and < 4%, respectively). The use of chat rooms also ranked low, with 69.2% of the respondents not using chat rooms in their online courses.

The content delivery tool used most frequently in online programs is Microsoft PowerPoint, with 92.3% of respondents reporting use of this software program. Approximately one-third of the respondents use Flash (34.6%; Adobe, San Jose, California) and student response systems (30.8%). Prezi was used by 15.4% of the respondents, followed by Soft Chalk and Elluminate, which were used by 7.7% of the respondents. Second Life was not used by any of the educators responding to this survey. Other delivery tools mentioned by educators include Panopto, Camtasia, and Wimba.

**Discussion**

The use of online education continues to increase in colleges and universities across the United States. According to the Sloan Consortium survey, approximately 5.6 million students were taking at least one online course in 2009.1 However, JRCERT indicated that 7% of the accredited programs were providing online learning courses in 2009.3 This survey research was conducted, in part, to determine the status of online education in the radiologic sciences and to ascertain growth in this area over a 3-year period. Although the results show that online distance education is still not prevalent in radiologic science education, it does suggest a substantial increase in online course activity. Of the educators responding to this survey, 38 (37.3%) worked at institutions offering an online course, demonstrating a 30% increase in the use of online courses in the radiologic sciences between 2009 and 2012.

These results imply a rapid and steady growth in the use of online teaching technologies; however, only a minority indicated they offered fully online courses. It appears that the status of adoption is to offer hybrid or blended courses, as more than 75% of the educators reported using online activities in this manner. Therefore, one may conclude that radiologic science educators are neither early nor late adopters of online educational technology, as described by Diffusion of Innovation, but perhaps fall in the middle of this continuum.

Educational institutions responding to this survey reported BlackBoard as the most frequently used LMS. BlackBoard is well established, has a strong presence in postsecondary institutions, and recently acquired both Angel and WebCT. In most instances, the system resides with the institution and not the specific educational program. This could change over time...
as institutions update the LMS programs across the entire enterprise to more robust systems.

The increased use of online teaching methods brings to light the importance of adequate educator instruction and continuing education in the use of interactive technologies for online content delivery. According to Debourgh, instructional strategies for online courses should include visual, aural, and text learning prompts and consist of interactive online discussion, coaching, collaboration, reflection, and activities that promote self-regulated learning.11

Results from the survey suggest that radiologic science educators have not fully made a transition to interactive technologies, as 92.3% of the respondents identified PowerPoint as the most frequently used delivery tool in the online programs. Although this popular tool helps to impart important information, it does not promote interactive learning. Online course instructors should use a variety of instructional technologies to engage the students in interactive, self-directed learning. The study results imply that although the use of online education has increased in the radiologic sciences, most educators might have created online instruction by simply posting PowerPoint presentations used in face-to-face lecture-based courses. This does not support the literature regarding collaborative learning theory.8,10,11,14

Although this survey indicates that 34.6% of the respondents use Adobe Flash and a few others use delivery tools such as Prezi, Soft Chalk, Elluminate, Panopto, Camtasia, and Wimba, which do promote student interactivity, radiologic educators appear to be making a slow transition to incorporating alternative interactive online learning strategies. One of the most frequently used instructional strategies in the radiologic sciences is discussion boards, with 80% of the respondents using this strategy in their online courses at least 50% of the time. However, live discussions via synchronous communication were rarely used in online radiologic science courses. Asynchronous discussions were used by the majority of educators (65.4%) responding to the survey. One-way prerecorded video-audio technologies such as interactive TV, podcasts, and webcasts were used by approximately 58% of the educators responding to the survey, but fewer than 25% of them reported the use of 2-way interactive video-audio systems such as Skype or compressed video.

Technology barriers are frustrating to those who are technologically insightful and even more so to those educators who may be somewhat technophobic.13 Online courses pose possible disruptions from technical problems; therefore, the ability to perform basic troubleshooting tasks is crucial in the success of online courses.14 Thus, educators must feel adequately prepared to engage in online education instruction.

The majority of educators responding to the survey reported that they received at least 1 to 4 hours of training prior to online course implementation. This helps in the initial design and implementation, but additional postimplementation training might be necessary to improve the success of online delivery. After an online course in health care is created, it must be evaluated and updated periodically. Only half the respondents to this survey reported completion of this critical postimplementation training regarding online technologies.

This limited training also could affect the educators’ ability to further integrate interactive learning activities into an online format. Collaboration with an instructional designer should be encouraged for improved course design and delivery; however, only one educator responding to this survey indicated this level of IT online support was available at his or her institution.

Limitations

The primary limitation to this study relates to the low number of respondents using online instructional technologies. Of the 102 surveys completed, 38 (37.3%) educators reported that their institution offered online courses. Of those 38 respondents, 26 completed all survey questions. This low number of responses limits the statistical power for analysis and the generalizability of these findings.

A second limitation was the overall response rate (27.95%). The survey was e-mailed to 365 instructors and 102 submitted a full or partially completed survey. This might be because of the electronic format, as some survey invitations could have been trapped in spam filters or blocked by institutional firewalls.

Conclusion

Radiologic science programs are continuing to use online education in their curriculum, with a 30% increase since 2009. However, there is a need to
increase the interactive learning opportunities for students enrolled in online courses. PowerPoint remains the most-used online tool, suggesting that instructors are taking face-to-face course materials and posting them online. PowerPoint provides an excellent platform to display and describe information but alone does not encourage student interaction.

It is critical for educators to demonstrate a willingness to adopt teaching styles conducive to online learning environments. These teaching styles must include interactive activities and encourage communication between fellow students and the instructor. Although a few instructors use Adobe Flash, Soft Chalk, and Prezi, radiologic science educators appear to be slow in adapting to interactive teaching methods. When designing an online course, student-to-student and student-to-instructor interaction is crucial for the success of the course.

In addition, the survey suggests that the amount of time instructors received in training in reference to online courses, both pre- and postimplementation, was low. Radiologic educators might not have a choice regarding the LMS adopted by their institution, but they should request additional training. Postimplementation training is critical for evaluating online course delivery strategies and improving the integration of interactive online tools into online courses. Collaboration with an instructional designer also is encouraged to ensure full functionality of the LMS.

**Implications and Needs for Further Research**

The use of online courses in the radiologic sciences is increasing. Therefore, a longitudinal study over a longer period could be useful to demonstrate trends in the use of online courses in radiologic sciences. It also would be helpful to investigate the adoption, integration, and use of new educational content delivery technologies.

This survey demonstrated a need for additional training in online education tools and learning management systems. These findings support previous studies regarding online education in the radiologic sciences, which indicated barriers such as a lack of preparation time, lack of student contact, and unfamiliarity with the technology. This is an area of need, and because many colleges and universities offer IT support, radiologic science educators should take advantage of these learning opportunities. Further research is needed to investigate the relationship between the type and amount of training instructors receive on the use of online technologies and their willingness to adopt interactive teaching strategies in online course delivery. In addition, a qualitative investigation into the barriers presented might be warranted.

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**References**


Heart disease is known more as a killer of men than women, but U.S. women have surpassed men in prevalence of and mortality from cardiovascular diseases. Although recent years have witnessed an upswing in education, awareness, and clinical research focused on heart disease in women, much work remains to reach a sufficient understanding of the differences in risk, presentation, and management of heart disease between the sexes to improve outcomes for women. Medical imaging has enhanced diagnosis and management of heart disease in women, especially by enabling less invasive approaches.

Most women believe that breast cancer is the greatest threat to their health, but cardiovascular disease has killed more women in the United States nearly every year since 1900 than any other disease. The only exception was in 1918, when a flu epidemic took more women’s lives than heart disease. Although breast cancer is an important clinical concern that can have devastating effects, heart disease takes a higher toll yet remains largely misunderstood in the female population.

Cardiovascular disease (CVD) also is responsible for the most deaths among men, but women now have higher prevalence and mortality from the disease than men.

Cardiovascular disease includes a number of thromboembolic diseases such as coronary artery diseases (angina and myocardial infarctions, or heart attacks) and cerebrovascular disease (strokes, transient ischemic attacks, and congestive heart failure). This article addresses many specific diseases related to the heart and cardiovascular system under the broad umbrella of “heart disease.” In addition, the article discusses the role of imaging in diagnosing and managing heart disease and issues radiologic technologists should consider specific to imaging women with heart disease.

Despite the prevalence of heart disease in women and its effect on quality of life and mortality, many disparities remain in awareness of the disease’s effect on women, clinical research, and care delivery. As clinicians continue to uncover the biological differences that account for differences in risk factors and disease presentation, they can better help women manage their risk factors for heart disease and

After completing this article, the reader should be able to:

- Describe the pathophysiological differences in heart disease between men and women.
- Explain problems with awareness of heart disease risk in women.
- List modifiable, nonmodifiable, and potentially modifiable risk factors for heart disease in women.
- Discuss disparities in heart disease research and care between men and women.
- Discuss the role of medical imaging in diagnosing heart disease in women.
- Explain special considerations for radiologic technologists when imaging women with heart disease.

Teresa G Odle, BA, ELS

Women and Heart Disease
work with researchers to improve outcomes among female patients.

Women account for more than half of the U.S. population. The National Institutes of Health (NIH) established a policy regarding inclusion of women in clinical research, but this did not happen until 1986. A 1990s cartoon depicted a physician meeting with a female patient and telling her that although he could access studies on “fruit flies, mice, hamsters, frogs, monkeys, and men” with her condition, it had never occurred to anyone to research the disease in women. Yet outcomes for women who have acute coronary syndromes remain much worse than for men, making a strong argument for increased clinical research on women and heart disease and particularly on sex-based differences in heart disease.

Plenty of statistics in the literature report the effects of heart disease on women’s morbidity and mortality. It is estimated that CVD affects more than 42 million women in the United States, which is 36.6% of the adult female population. Coronary artery disease (CAD) affects more than 7 million women. In 2007, reports estimated that approximately 1 woman died every minute in the United States from CVD. The total represents more deaths than from the combined causes of cancer, chronic lower respiratory disease, Alzheimer disease, and accidents. Still, risk of death from heart disease remains higher for older women than for younger ones, and onset of heart disease occurs almost 10 years later in women than in men.

Heart disease also is the leading cause of death for women around the developed world. In 2008, approximately 17.3 million people died from CVD worldwide, accounting for 30% of all deaths. Women accounted for half of these deaths. With increasing awareness, education, and management, women’s mortality from CVD in the United States declined from 2000 to 2007. There still is much to learn, however, about differences in the presentation of heart disease in women and much to gain toward closing the gaps in disparities in disease management and research.

**Pathophysiology and Disease Presentation**

There continue to be marked disparities in heart disease outcomes and care delivery between men and women. A number of causes could explain these differences, but one of the underlying reasons that risk factors for and presentation of many heart diseases differ between men and women can be traced to simple biology. Pathophysiological differences exist between the sexes in clinical presentation of disease, diagnostic procedures, and how men and women respond to treatment. Important factors such as vascular and myocardial physiology, structure, and function are examples. What’s more, men and women differ at the most basic cellular levels and even in responses or reactions to medications.

From the time they are forming in utero, men’s and women’s sex differences are apparent. Aside from reproductive organs and functions, there are important genetic differences. Genes on the Y chromosome are expressed only in men, and some genes are expressed on both X chromosomes in women. Certain genes are expressed differently in women and men, and certain genes escape inactivation by the X chromosome, which means higher levels of these genes’ products could be produced in women than in men. Sex-specific genetic effects are being studied at the molecular level.

Scientific evidence now supports sex differences in the biology of men’s and women’s bodies throughout their life span. Sex differences are those related to how living organisms are classified and the basic XX chromosome classification for women and XY classification for men. The chromosome distinctions apply to many nonmodifiable risk factors for heart disease that will be discussed in more detail. Modifiable risk factors for heart disease and barriers to care can be related to gender differences or how a person self-presents, along with the social and cultural aspects of that representation over a continuum.

Many of the differences between vasculature of men and women can be attributed to female sex hormones. Cardiac tissue has nuclear receptors for sex hormones. Female hormones fluctuate throughout a woman’s life cycle, and estrogens can cause vasodilation. Circulating estrogen levels affect vasodilation and blood pressure when the levels fluctuate because of a pregnancy, the menstrual cycle, or hormone replacement therapy.

Clinicians point to several cardiovascular abnormalities that appear to be more common in women,
including vasospastic disorders, Raynaud phenomenon, migraine headaches, and some forms of vasculitis. Women’s vasculature is smaller and stiffer than men’s, which can impair coronary reserve flow.4

Researchers also have studied at length the sex differences in pharmacokinetics. Therapeutic drugs affect men and women differently. Women tend to have higher incidence of adverse drug reactions, and there have been reports of the complex effect of a patient’s sex on how drugs metabolize in the liver and gastrointestinal tract. There likely are sex differences in how women and men excrete medications and absorb topical medications through the skin.4,12

Cardiovascular Diseases

Sex differences also play a role in the pathophysiology and disease presentation of many forms of cardiovascular disease. The following is a summary of some of the differences in important diseases and conditions that lead to cardiovascular disease and mortality.

Atherosclerosis

The buildup and hardening of plaque in the arteries’ inner walls leads to CAD and eventually can cause acute coronary syndrome (heart attacks and unstable angina).7,14 As atherosclerotic disease progresses, molecular and histologic dynamics of the plaque continuously change. Some cells die, and debris from the dying cells accumulates. This adds to the inflammatory response already initiated by the artery’s stressed endothelium and response of white blood cells.14

Studies have shown that women can have more risk factors for atherosclerosis and acute coronary syndrome, the broad term for sudden blockage of blood supply to the heart, but harbor less plaque than men.15 Plaque rupture (a lesion rich in lipids with a necrotic core and a thin, ruptured fibrotic cap) is more common in men, but plaque erosion, which is an acute thrombus directly on the vessel’s intima, is more common in women (see Figure 1).7,16 This likely is because younger women are more prone to erosion than rupture.

Once a woman reaches menopause, the incidence of plaque rupture increases, and 80% of coronary thrombi are caused by plaque rupture in women older than 50 years.16 The change is partly explained by the effects of estrogen on gene expression and protein production and activity.9 The difference in plaque mechanics could partly explain sex differences in outcomes following acute coronary syndrome.7

Hypertension

High blood pressure is a significant risk factor for CAD, along with coronary heart failure, stroke, and other
Women and Heart Disease

Heart diseases or conditions that lead to heart disease. Most notably, hypertension is a defining condition of the metabolic syndrome, the group of conditions that puts people at risk for heart disease and diabetes. Risk for hypertension increases with advancing age for both sexes. Genetics also play a role in hypertension risk, and sex differences are apparent until women reach menopause. Many studies have shown that as a rule, women have lower blood pressure compared with men throughout their lives until menopausal age. By the time they reach menopause, women no longer have an advantage over men in hypertension incidence, and the most likely reason is a decrease in the protective effects of female sex hormones as a result of menopause.

Coronary Artery Disease
In general, the chest pain, pressure, and squeezing that represent angina pectoris are symptomatic of myocardial ischemia. The chest pain from stable angina usually occurs upon exertion and is eased with rest, and unstable angina typically occurs when a patient is at rest or performing minimal activity. Angina is the most common major presentation of coronary heart disease among women. Some reports have stated that the metabolic syndrome is associated with CAD in women more than obesity. Other biomarkers might contribute to the presence or severity of CAD, particularly in women. Women who have acute coronary syndrome typically have elevated C-reactive protein and brain natriuretic peptide, but men have different elevated biomarkers. Women tend to have more small vessel disease, vascular inflammation, and congestive heart failure, but men experience more plaque rupture, platelet-rich thrombi, and microembolization.

Peripheral Artery Disease
Men have a higher risk of peripheral artery disease than women, and only about 10% of patients of both sexes complain of pain from claudication. Up to 66% of elderly women with the condition are completely asymptomatic. Hypertension is an important risk factor for peripheral artery disease, and women have a higher age-adjusted risk than men.

Myocardial Infarction
Recent studies have confirmed 9 risk factors that account for more than 90% of myocardial infarctions (MI) in both sexes and 94% of those that occur in women. The risk factors are cigarette smoking, hypertension, diabetes, abdominal obesity, psychosocial factors (such as home, work, or financial stress), poor fruit and vegetable intake, lack of exercise, alcohol intake, and apolipoprotein B/apolipoprotein A-I ratio. The strength of these risk factors’ associations with heart attack risk is nearly equal among men and women, with the exception of diabetes, which has a much stronger association for women. Young women tend to have a lower risk of short-term mortality from an MI than young men do, but as women age, the mortality risk equalizes for the sexes. Women are more likely to have a recurrent MI and be disabled by heart failure after the recurrent heart attack.

Heart Failure
When the heart cannot meet the body’s requirements for normal filling pressures, it is known as congestive heart failure. At 40 years old, women have a higher lifetime risk of developing heart failure than men do. The combined effects of hypertension, steeper relationship of blood pressure to blood volume, and more diastolic dysfunction likely explain why women tend to have congestive heart failure more often than men do despite the fact that women have better left ventricular function. Alcohol could be more toxic to the myocardium in women than in men, so the fact that alcoholic cardiomyopathy is more common in men could coincide with greater incidence of alcoholism in men. Women likely require a lower total intake of alcohol for the same effects to occur.

Arrhythmia
The effects of sex hormone receptors on the heart’s electrophysiology differ between men and women, causing decreased QTc intervals in men after puberty but increased QTc intervals in women only after menopause. Women also have shorter atrial refractoriness, particularly after menopause. Women have a slightly higher incidence of atrial fibrillation than men, along with a tendency toward more strokes related to atrial fibrillation. Some of women’s higher incidence of atrial fibrillation might be attributed to a correspondingly higher incidence of obesity or to the pathophysiological changes that occur following menopause.
Cerebrovascular Disease

The lifetime risk of dying from a stroke is almost double for women compared with men. Women account for slightly more than 60% of all stroke deaths in the United States. Risk factors for cerebrovascular disease are similar to those for cardiovascular disease, such as smoking, diabetes, hypertension, and inactivity. Stroke risk related to smoking increases depending on how heavily a woman smokes. It takes 5 years for risk to return to that of nonsmokers after a woman quits smoking.1 Use of hormone replacement therapy also increases stroke risk in women.9

Women older than 60 years of age, those with diabetes, or those who have symptoms lasting more than 10 minutes during a transient ischemic attack are more likely to have a stroke following a transient ischemic attack.7

Spontaneous Coronary Artery Dissection

Spontaneous coronary artery dissection (SCAD) is an infrequent cause of acute coronary syndrome with uncertain origin and clinical features. A hematoma or dissection in the coronary intima or media are hallmark findings. SCAD typically affects younger otherwise healthy people, particularly women in peripartum or postpartum states. In men, SCAD appears most often following extreme physical activity. In a small study by Tweet et al, all recurrences of SCAD were in female patients.8 In more than half of cases, SCAD is life-threatening, and diagnosis is complicated by a bias regarding chest pain in young patients, particularly young women. That bias leads to misdiagnosis or under-referral of the patients for cardiac evaluation.8

Heart Disease Risk

In 2007, the American Heart Association’s evidence-based algorithm for classifying CVD risk in women was updated. An American Heart Association committee classified risk in 3 categories (see Box).4 Not all coronary events that occur in women can be explained by traditional CVD risk factors, and many of the tools designed to assess risk for MI are less effective at predicting MI risk in women.9 Assessing risk of acute coronary events in women could be lacking because of sex-based differences,9 and recent guidelines support focusing on long-term risk for

Box

American Heart Association Guidelines
CVD Risk Classification in Women

Women at high risk have:

- Clinical manifestations of coronary heart disease, cerebrovascular disease, or peripheral arterial disease.
- An abdominal aortic aneurysm.
- Chronic or end-stage kidney disease.
- Diabetes.
- A 10-year predicted risk of CVD > 10%.

At-risk women:

- Smoke cigarettes.
- Have an average systolic blood pressure > 120 mm Hg, a diastolic blood pressure of at least 80 mm Hg, or are being treated for hypertension.
- Are obese, particularly in the upper abdominal area.
- Have poor diets.
- Are physically inactive.
- Have a total cholesterol ≥ 200 mg/dL, high-density lipoprotein cholesterol < 50 mg/dL, or are being treated for dyslipidemia.
- Have metabolic syndrome.
- Have a first-degree male relative < 55 who had premature CVD or a first-degree female relative < 65 with premature CVD.
- Show evidence of advanced subclinical atherosclerosis.
- Demonstrate poor exercise capacity on treadmill exercise test or abnormal heart rate recovery after exercise ceases.
- Have history of gestational diabetes, preeclampsia, or pregnancy-related hypertension.
- Have a systemic autoimmune collagen-vascular disease such as lupus or rheumatoid arthritis.

Women with ideal cardiovascular health:

- Have blood pressures < 120/< 80 mm Hg with no treatment.
- Test < 200 mg/dL total cholesterol with no treatment.
- Have a fasting blood glucose < 100 mg/dL with no treatment.
- Reach physical activity goals > 150 min/wk of moderate-intensity exercise, > 75 min/wk vigorous intensity, or a combination of both.
- Abstain from smoking.
- Follow a healthy diet similar to the Dietary Approaches to Stop Hypertension diet.

Abbreviation: CVD, cardiovascular disease.
CVD in women vs a more short-term 10-year risk for coronary heart disease.\

Risk factors for many cardiovascular diseases are categorized as modifiable or unmodifiable. For example, people cannot alter their age or family history. Other risk factors are potentially modifiable. A woman might have a genetic predisposition to high cholesterol, for example, but she can control cholesterol levels with exercise and nutrition habits. Even sex-specific differences in first-degree relatives who have had cardiovascular diseases differ depending on the sex of the relative and the patient.\

Nonmodifiable Risk Factors\

Age is likely the most powerful risk factor for heart disease, especially for women. Men have a higher risk for heart disease through age 59 years, but at age 60 years, risk equalizes between the sexes and then becomes higher for women as they age than it is for men.\

Having a family history of MI or stroke significantly affects risk of the diseases for men and women. Family history is a complex factor that likely expresses differently in men and women but is still being investigated. The distinctions between men and women at the chromosomal level point to multiple differences in basic cellular biochemistry that can affect heart disease and other health. Researchers have observed differences in enzymes involved in plaque rupture and how often genetic polymorphisms contribute to cardiovascular events based on the influence of sex differences. The Institute of Medicine’s Committee on Understanding the Biology of Sex and Gender Differences has recommended that research be conducted to determine the functions and effects of genes linked to the X chromosome and Y chromosome and how genetic sex differences influence cells and organisms to affect disease susceptibility.\

Migraines have been shown to have a complex relationship with cardiovascular disorders. On one hand, migraines have been identified as a risk factor for ischemic stroke and CAD. On the other hand, certain cardiac anomalies have been investigated as causes of migraines. Among these are patent foramen ovale (a relatively common small opening in the heart since birth), cardiac and pulmonary right-to-left shunt, and structural anomalies. In the Women’s Health Study, women who had migraines with auras had a relative risk for ischemic stroke of 1.7 compared with controls who did not have migraines. The risk was highest among younger women — those aged 45 to 55 years (45 years was the minimum age enrolled in the study). Younger men who have migraines also are at increased risk for stroke compared with other men their age.\

Modifiable Risk Factors\

Lifestyle factors that increase risk are modifiable. Smoking increases coronary heart disease risk factors for men and women, but a large review demonstrated that the risk for women who smoke is 25% higher than for men who smoke. Plaque erosion is associated with smoking, especially in women who smoke. Smoking is positively correlated with sudden coronary death, particularly in women aged younger than 50 years who have plaque erosion. According to a 2011 survey by the Centers for Disease Control and Prevention, more than 1 in 6 American women aged 18 years or older smoked cigarettes (16.5%), and 35% of girls in ninth grade had smoked at least one cigarette.\

Stroke risk from migraines presents an excellent example of how nonmodifiable and modifiable risk factors interact: Although young women with migraines are at increased risk, those who smoke or use oral contraceptives and have migraines are at much higher risk for stroke.\

Being overweight or obese increases risk for metabolic syndrome, diabetes, and CVD. A 2005-2006 National Health and Nutrition Examination Survey reported that slightly more than 35% of women in the United States were obese (BMI > 30 kg/m²), and a 2005 study from the National Center for Health Statistics reported that 12% of women engaged in no moderate to vigorous leisure-time activity.\

Salt intake is a modifiable risk factor for hypertension, and thus CVD. Although higher dietary salt intake can increase blood pressure in men and women, it tends to have more effect in men. The explanation might have to do partly with differences in blood pressure measurement, but likely is explained by the interaction between sex hormones and the renin-angiotensin system’s regulation of cardiovascular function and blood pressure. The renin-angiotensin system helps to regulate the body’s fluid balance and blood pressure through release of the kidney enzyme.
renin and its conversion of the liver’s angiotensinogen into angiotensin I. Estrogen might upregulate the expression and activity of certain components of the renin-angiotensin system.17

**Potentially Modifiable Risk Factors**

Although type 1 diabetes is nonmodifiable, the more common type 2 diabetes can be attributed to both modifiable and nonmodifiable causes. Age, family history, and race or ethnic background are among nonmodifiable risk factors for diabetes. Being overweight or obese, remaining physically inactive, having hypertension, and smoking are among modifiable factors.23 More than 10% of women older than 20 years have diabetes, but about 25% of those women do not know they have the disease. Diabetes is such a significant risk factor for cardiovascular disease that it is considered a “cardiovascular disease equivalent.” Diabetes affects cardiovascular disease risk more for women than men at a risk ratio of 3.5 for women vs 2.4 for men.1

A study in Africa by Gombet et al found that age, female sex, a proinflammatory state (promoting inflammation), and the more sedentary lifestyle associated with rural to urban migration were significant risk factors for metabolic syndrome, and thus for diabetes and CVD.17 A trial that was part of the Women’s Ischemia Syndrome Evaluation (WISE) study followed 580 women for 4.7 years after coronary angiography. Proinflammatory markers (from cytokines in blood samples) did not help predict the extent of angiographic CAD but were strong predictors of mortality risk. Another WISE study looked at obesity and metabolic syndrome in women and found that body-mass index (BMI) was strongly related to metabolic status, but only metabolic syndrome (not obesity alone) was associated with CAD risk.18

Hypertension is potentially modifiable, partly because of factors such as salt intake that can affect blood pressure. Blood pressure also can be treated with behavior modification and medication, but women as a population are undertreated.9

**Psychosocial Risk Factors**

Sundell et al investigated the occurrence of depressive symptoms among women in a cardiac rehabilitation program and found a strong relationship between depression and angina pectoris.24 Women with angina tended to have higher anxiety levels.24 The Framingham Offspring Study found that anxiety did not contribute significantly to atrial fibrillation in men or women but was a significant risk factor for mortality in both sexes.3 Sundell et al noted a higher incidence of depression in women with CAD than in men with heart disease. However, depressed women were more likely to have family histories of heart disease than those who were not depressed.26

In fact, depression is a risk factor for cardiac events along with being an outcome of major cardiac events. Naqvi et al concluded that female sex significantly predicts depressive symptoms and severity of symptoms following unstable angina or MI events.25

Many people who have chronic diseases experience depression, anxiety, stress, and other psychosocial issues that can make it more difficult to manage their diseases. Some research has suggested that women might experience more psychosocial problems after an acute cardiac event than men do. Mead et al convened focus groups consisting of male and female heart patients who were considered low-income and underserved.26 They found that both sexes experienced depression and a wide range of negative emotions, life stressors, and other social factors following a cardiac event.

The study by Mead et al found many similarities between men and women but several differences as well. For example, women were more likely to express their fears at length, and men talked more about anger. Much of the fear women experienced appeared to be related to feelings that they were unable to control their health, but men’s anger seemed to relate more to concerns about self-worth, particularly as income earners. Women expressed that they felt a great deal of stress because of cumbersome medication regimens and changes in lifestyle. They also felt anxiety about not fully understanding their heart diseases. Social isolation as a result of their disease was more of a concern for women than for men.26

**Disparities in Care**

The term “health disparities” generally refers to differences in indicators of health among population groups. Often, it is applied to certain races or cultures or people living in a particular geographic area or within a socioeconomic group. Researchers have been
documenting health disparities for at least 200 years and have more recently reported health disparities regarding the sexes and heart disease care. A myth once prevailed that heart disease was a “man’s disease.” Although progress has been made in the understanding of women’s heart disease, a gap remains in awareness of how risk, disease presentation, and mortality differ between men and women. This gap is particularly apparent among women and their physicians, yet awareness is important to preventing and treating CVD. Disparities also continue to some extent in the representation of women in clinical research trials and in the management of CVD among female patients.

**Awareness**

Managing CVD and adhering to clinical guidelines requires that women and their physicians be aware of the disease risk and that physicians be aware of guidelines and knowledge about how to correctly assess and assign women’s heart disease risk.

In 1997, an American Heart Association survey found that only 7% of women reported CVD as the disease with the most health and mortality risk. The American Heart Association developed several efforts such as the Go Red For Women campaign aimed at improving women’s awareness of CVD risks. The education significantly improved women’s understanding of CVD’s contribution to female mortality. Nevertheless, a 2009 survey of women reported that only about half correctly identified CVD as the leading cause of death among women; only 1 in 6 surveyed correctly identified CVD as women’s leading health risk. The American Heart Association has reported that most primary care physicians do not recognize the prevalence of coronary heart disease among women. Another study of 500 randomly selected physicians showed that only 1 in 5 were aware that more women than men die each year from heart disease. Historically, physicians have not received a significant amount of training specific to sex-related differences in cardiac incidence and care.

When women experience coronary symptoms, they often delay seeking emergency care. The first step is for women to recognize MI symptoms. A recent national survey by the American Heart Association reported that only 53% of women said the first action they would take if they thought they were having a heart attack would be to call 911. In addition, there is a fundamental lack of understanding among health care providers about the mechanisms of early-stage CVD and symptoms in women.

**Clinical Trial Representation**

As recently as the 1990s, relatively few clinical studies were available to assist clinicians in treating women with CVD. Most reports from trials have included no more than 30% female participants. A systematic review of trials regarding MI from 1966 to 2000 demonstrated a significant difference in how many women vs men had MIs compared with female participants represented in trials. Clinical studies are important for improving morbidity and mortality from diseases, particularly CVD, and when women are underrepresented, they are treated based on evidence extrapolated primarily from studies involving CVD in men.

Clinicians often have had to rely on evidence from trials that mostly or entirely enroll men. For example, the bulk of evidence supporting management of heart failure traditionally has come from trials involving men and a predominance of left ventricular systolic dysfunction. Women were underrepresented in trials that served as the basis for updated heart disease prevention guidelines in 2007. The underrepresentation of women in trials on which clinical guidelines are based is more problematic when the guidelines are used globally. This is because the results are further extrapolated to address CVD in women who have different cultural and racial-ethnic backgrounds.

The ongoing Framingham Heart Study began in 1948 but is an exception in its representation of female participants. The original random sample included 2873 women and 2336 men. The study and its offspring studies have helped to identify major risk factors for CVD. The improvement in survival rates for women with CVD from 2000 to 2007 could be partly attributed to heightened application of evidence-based therapies and preventive interventions targeted at women.

Enrollment of women in clinical trials that could examine men and women with preserved systolic function helped in developing therapies that were more effective for women with heart failure. In 2007, representatives from academia, regulatory agencies, and industry met to develop strategies for improving
representation of women in CVD clinical trials and to ensure that clinical trial results are reported by sex.9

**Treatment Disparities**

Although awareness has improved somewhat, significant disparity remains between the sexes in terms of CVD treatment, and more progress has been made overall in decreasing the number of deaths from heart disease among men than among women. Women are less likely to receive the appropriate treatment for CVD and are more likely to die from open heart surgery or within 1 year of having an MI.1

A lack of awareness and clinical inertia could contribute to physicians failing to adhere to practice guidelines regarding cardiac care for women.27 For example, a study by Barnhart et al examining barriers to CVD preventive treatments revealed that half of OB-GYN and one-third of internist respondents were unaware that tobacco use is the leading cause of MIs in younger women (mean age 40.3 years).3,27

Primary care physicians often do not have cardiac risk prevention services integrated into their routine care. In a recent study, less than two-thirds of internists and slightly more than 50% of OB-GYNs said they had suggested quit dates to patients who wanted to quit smoking tobacco. Most reported that they had discussed diet and exercise as forms of weight control with their patients. This conflicts with patient surveys, however, which report that only about 42% of patients having physical examinations in the previous year were advised by their physicians to lose weight.27

In general, women are undertreated for many heart diseases such as atrial fibrillation.1 There have been reports of disparities in surgical and nonsurgical treatments for CAD in men and women,11 including reports of disparities in revascularization following coronary angiography or surgery.30

CAD presentation differs significantly between men and women, often leading to delayed diagnoses and treatment.11 Young women in particular might seek treatment for symptoms but fail to receive a referral for cardiac care. Physicians might incorrectly attribute symptoms among the young female population to another cause.16 Older age at disease onset, delays in seeking treatment, and lower intensity of treatment from physicians likely combine to contribute to poorer outcomes for women.1

Women’s perceived risk for heart disease vs actual risk causes many of the differences between the sexes in the use of appropriate preventive measures for CVD.30 Because women wait longer before seeking treatment for CVD, they are more likely to have poorer outcomes than men.1 Improving physician awareness and education can help offset women’s lack of risk appreciation,30 but women still need to understand risk and symptoms. Studies have shown that only 48% of women surveyed could correctly identify optimal blood pressure levels.9

**Barriers to Care**

It is not completely understood whether biological and pathophysiological differences between the sexes cause health disparities. There have been reports, however, of women facing greater delays in care and receiving fewer cardiac catheterization referrals than men. Increasingly, evidence has shown that socioeconomic and cultural factors affecting women, along with low awareness of heart disease in women, have played important roles in care disparities between men and women.4

Both men and women can face socioeconomic barriers to care, but some are specific to women. For example, women often have trouble adhering to heart disease prevention guidelines because of family caregiving responsibilities, stress, sleep deprivation, fatigue, and a general lack of personal time.4 In addition, some psychosocial factors specific to women interfere with adherence to medical recommendations, particularly regarding lifestyle modifications. Women who have low incomes or significant social disadvantages are at higher risk for depression and anxiety, which can exacerbate heart disease.26

Ozminkowski et al investigated why women fail to receive their annual visits to manage coronary heart disease.11 The authors interviewed a small group of women aged 65 years or older who were eligible for an annual visit to manage their CAD and who had not visited the office for CAD management in the past 12 months; the authors also surveyed 100 physicians. Among women, skepticism or denial regarding their heart problems was the top barrier to presenting for their management appointments in the emotional barrier category, and having to call to make the appointment was the most common practical barrier. Many also cited that they were dealing with more
Women and Heart Disease

Potential heart disease symptoms and comprehensively assess CVD risk factors. The medical history should include questions regarding family history of heart disease and known risk factors for CVD. Tools such as the Framingham Risk Assessment can use in-office assessment information along with laboratory findings from a fasting serum lipid panel to calculate CVD risk.1,8 The Framingham calculator has limitations, however. The algorithm is designed only to calculate 10-year risk for death from MI and coronary heart disease; it does not include family history, and it might score women who have subclinical heart disease as low risk for CVD. Current guidelines focus more heavily on long-term risk and are based on evidence that risk for stroke and heart failure among women who are middle-aged and older typically exceeds risk for coronary heart disease.8

Cardiac biomarkers also can be ascertained to help determine whether a patient is in need of emergency care when presenting with chest pain. Typical cardiac biomarkers include myoglobin, creatinine kinase, and troponins.14 A recent review of 8 randomized trials enrolling more than 3000 women found that women benefit significantly from invasive interventions when they have positive biomarkers but do not benefit if biomarkers are negative. Men tend to benefit from invasive management strategies whether their biomarkers are positive or negative.9 Research is lacking as to the most effective strategy to rule out a CAD diagnosis in women.9 Once adjusted for age, more women than men have angina symptoms. However, angina-like symptoms precede only about 20% of MIs.1 Exercise electrocardiogram (ECG) stress testing often is used to first investigate women with cardiac symptoms such as stable angina, but stress testing recommendations usually are based on studies performed primarily on men.30 Further, there are frequent reports of ECGs being less accurate in women and resulting in high false-positive rates, along with some reports that women who have heart disease are more likely than men to have normal ECG readings. Exercise stress tests are less effective at detecting single-vessel coronary disease, which occurs more often in women than in men.5,35 Exercise testing works well as a first test in diagnosing stable angina in women, but coronary angiography also should be part of the initial investigation. Still, studies have shown that women are 40% to 50% less

Diagnosing Heart Disease in Women

Education for women and physicians regarding awareness of women’s heart disease should include information about recognizing symptoms of CVD, and particularly MI, that are unique to women.32 Both sexes tend to experience chest pain as the most common symptom.1 They also might experience intense pressure or squeezing in the chest; pain that radiates to the neck, shoulder, back, arms, or jaw; palpitations; heartburn; dyspnea; nausea; dizziness; vomiting; or abdominal pain.

Women also experience more subtle symptoms such as lightheadedness, a squeezing sensation in their backs, or shortness of breath even when at rest. They also might break out in a cold sweat.9,32 Women are more likely to have gastrointestinal symptoms, sweating, fatigue, and arm or shoulder pain in the absence of chest pain.9

Diagnostic Strategies

Physicians may be less likely to consider CVD in women who have CVD symptoms and therefore might not pursue the appropriate investigation to exclude heart disease.1 Diagnostic work-up varies depending on the patient’s symptoms and suspected disease but should include a thorough medical history to identify seemingly important health issues and that they did not have a good relationship with their cardiologists. Women also noted that they tend to care for others rather than themselves.

Of physicians surveyed, 54% stated that they believe women face barriers to care that men do not face. The physicians who believed that their female patients faced barriers were asked to name the barriers from a list generated by the interview of female patients. The most common barrier physicians chose was fear of treatment, closely followed by denial of heart disease, and third was putting other family members first.11 Access to care can be even more difficult for women in less developed countries. In Africa, for example, lack of awareness regarding CVD in women is a significant barrier to care, as is distance to care; lack of funding for travel; ill-equipped facilities, particularly for dealing with women who develop heart disease during pregnancy; and the fact that many women work in informal sectors of the economy and many countries lack government health insurance.31
likely than men to have an angiogram, regardless of the results of exercise tests. The Duke Treadmill Score is commonly used in the United States and appears to work equally well for both sexes. The test has been shown to accurately quantify risk in younger women and to be particularly useful in ruling out CAD in women at low risk for heart disease. Alternatives to exercise stress tests are stress nuclear imaging, stress echocardiography, computed tomography (CT) angiography/electron beam CT, and magnetic resonance (MR) imaging. Many imaging modalities also are used to confirm diagnoses or exclude CVD.

**Imaging**

Advances in cardiac imaging techniques have improved diagnosis of heart disease in men and women. Imaging modalities such as myocardial perfusion imaging (MPI), echocardiography, CT, MR, and angiography have enhanced diagnosis and management and enabled less invasive approaches.

In general, imaging with stress testing is useful in women who have symptoms of CAD and are at intermediate risk or high risk of heart disease. In an American Heart Association position statement, stress-gated myocardial single-photon emission CT (SPECT), in which an ECG guides image acquisition while the patient is at rest and under cardiac stress, was stated to perform similarly to stress echocardiography in diagnosing CAD in women and presented similar risk in men and women.

Several imaging methods have been suggested to help better classify heart disease risk in women but have not been sufficiently studied or shown to significantly improve outcomes. Among these are coronary calcium scoring and carotid ultrasonography, which can help reclassify women assigned low-risk status according to tools such as the Framingham Risk Assessment. In addition, although risk factors for CVD specific to women have been identified, researchers also have yet to determine how useful screening for these risk factors can be in improving outcomes for female patients.

**Imaging Modalities**

When diagnostic medical imaging can assist in differential diagnosis of CVD for women in the emergency or nonemergency setting, the following imaging modalities might be used.

**Chest Radiography**

Chest radiography usually follows an ECG for patients who come to emergency departments with suspected unstable angina. The chest radiograph can help physicians exclude other causes of chest pain, particularly in patients who have acute but nonspecific chest pain and low probability of CAD. The radiologist might identify noncardiac causes for the chest pain.

A chest radiograph also is helpful in evaluating valvular heart disease by showing calcified valves, pulmonary venous congestion, or changes in ascending aortic root size. If a patient has mitral stenosis, the chest radiograph might show evidence of an enlarged left atrium and increased pulmonary congestion with interstitial edema.

**SPECT MPI**

SPECT is a nuclear imaging method that uses radio nuclides such as Thallium-chloride and Technetium-labeled agents. Resting SPECT is less sensitive than stress SPECT imaging at diagnosing CAD in women if a patient’s pain has subsided. Newer software algorithms have allowed for shorter SPECT image acquisition times or lower patient doses. SPECT MPI or other perfusion imaging generally is recommended for women who report angina symptoms but who have normal resting ECG results. Gated SPECT can assess and calculate left ventricular function, which is critical to determining the cause of defects in ventricular function. The modality also can assess myocardial viability, which can be useful to physicians when assessing patients for coronary artery bypass grafting.

Shaw et al investigated the use of SPECT MPI vs exercise treadmill testing in a group of more than 800 women who were symptomatic of suspected CAD. The authors found that near-term (ie, 2-year) clinical outcomes were similar for exercise treadmill testing and stress MPI testing but that treadmill testing was significantly less expensive to perform. The authors expressed that they could not determine whether outcomes would be similar between the 2 types of testing for women who were at higher risk and might have been more appropriate candidates for MPI.
Although contrast-enhanced coronary CT angiography (CCTA) can be a reasonable alternative for some patients, the risk of cancer from the examination’s radiation is higher for women, particularly younger women. Breast cancer is of particular concern from CCTA. Recent advances in CT technology are addressing dose from CCTA but are not yet fully proven as comparable to standard CCTA for all patients.

The total effective dose from CCTA has been estimated from 2.1 mSv to 21.4 mSv. In 2008, new International Commission on Radiation Protection guidelines suggested that breasts might be more radiosensitive than previously thought, and renewed emphasis has been placed on minimizing radiation to the breasts by optimizing technique.

According to the American College of Radiology, CCTA may be indicated for patients who have:

- Unexplained or atypical chest pain that might originate in the coronary artery or with low or intermediate likelihood of CAD based on age, sex, or risk factors.
- Typical or atypical chest pain and normal or equivocal stress test, along with normal or equivocal ECG findings.
- Severe and unexplained chest pain in the emergency setting and no clinical history of CAD.
- Newly diagnosed cardiomyopathy or heart failure with ischemia to determine the cause.
- Need of preoperative or postprocedural evaluation of the coronary arteries, cardiac structures, and thoracic anatomy.
- Cardiac or coronary artery anomalies.

CT is well established in detecting aortic aneurysms, aortic dissections, pulmonary emboli, and other cardiopulmonary diseases. One of the concerns regarding use of CCTA before coronary catheterization is that should intervention be required, the patient has to undergo 2 procedures, negating CCTA’s usefulness. A recent study involving 15,000 patients from the Coronary CT Angiography Evaluation for Clinical Outcomes database demonstrated that few of those who had mild or moderate CAD required invasive procedures. The study examined whether CCTA could be used as a gatekeeper examination before sending emergency department patients for more invasive catheterization procedures. The study evaluated practice patterns and use of resources for 2.3 to 11.2 years on patients old enough to qualify for Medicare. CCTA can target patients at high risk in need of intervention. They found that using CCTA as a gatekeeper examination would be less expensive and is less invasive.

In a study investigating which patient characteristics could affect image quality and diagnostic accuracy when using multidetector CT to detect CAD vs coronary angiography, Dewey et al found that BMI, patient ethnicity, mean scan heart rate, and breathing artifacts affected image quality, but a patient’s heart rate, calcium artery calcification score, and sex did not affect accuracy of the CT images.

Echocardiography

Stress echocardiography is effective and safe in women. It is equivalent to SPECT MPI in the emergency setting for patients with low to intermediate risk of an acute coronary event. Transesophageal and transthoracic echocardiography frequently help define ventricular wall motion abnormalities. The examinations may be conducted with or without pharmacologic stress. In particular, transthoracic echocardiography without stress provides excellent information to exclude acute coronary syndrome with no use of pharmacological agents or ionizing radiation and is a low-risk screening choice for women. Tissue Doppler imaging has made echocardiography more useful for detecting subclinical heart failure. Research has shown that reference values for annual velocities should be specified by age and sex.

Ultrasonography

Intravascular ultrasonography can show plaque in coronary arteries that is determined as “normal” on angiograms. Arterial duplex Doppler sonography can provide real-time images to localize atherosclerotic disease. Ultrasoundography also can help assess stent or graft patency after revascularization, which can be particularly helpful in women, who often have complications following endovascular repair.

MR Imaging

MR is limited in its usefulness for cardiac imaging in the emergency setting because of equipment availability.
Delayed postcontrast and edema-weighted imaging can help definitively assess the extent, size, and distribution of MI. MR imaging also can help identify aortic dissection and other noncardiac findings of chest pain. In nonemergency settings, MR angiography (MRA) may use contrast or noncontrast protocols to identify vascular pathology. MRA may be used to evaluate, assess the severity of, or follow up on vascular system diseases. MRA is a useful alternative for women who have contraindications to CCTA or to more invasive coronary angiography.

Coronary Angiography
Cardiac catheterization with coronary digital subtraction angiography is the most proven method to date at demonstrating CAD and allowing for immediate therapeutic intervention. During catheterization, the images can demonstrate narrowing of the vessel lumen along with the number of diseased vessels. Coronary angiography is invasive, however, and is rarely indicated when patients have a low risk or probability of CAD. Less invasive CCTA and MRA methods have essentially replaced diagnostic angiography.

Women are at higher risk of bleeding complications from percutaneous coronary interventions than men are. The Society for Cardiovascular Angiography and Interventions has a small section in its guidelines about percutaneous coronary interventions devoted to women as a special population. The section confirms that women undergoing these invasive procedures have more risk factors compared with men. The guidelines point out that drug-eluting stents appear to work as well in women as in men.

Emergency Imaging
Acute chest pain is a frequent symptom of patients in emergency departments. Clinical symptoms can suggest acute myocardial ischemia or aortic dissection, along with a possible pulmonary embolism. CCTA can be highly specific and sensitive for detecting clinically significant CAD but usually is not the first imaging modality chosen for acute chest pain in the emergency setting. American College of Radiology appropriateness criteria suggest SPECT MPI at rest and under stress and coronary arteriography as the highest-rated imaging methods for acute pain suggestive of coronary syndrome.

Unstable angina, ST-segment elevation MI (STEMI), or non-STEMI could be indicated by acute chest pain, and a rapid, accurate diagnosis is critical. Once the ECG and cardiac biomarkers suggest acute coronary syndrome, the patient should have percutaneous intervention within 90 minutes of arriving at the hospital, and if there are changes to the ECG or clinical symptoms, the patient might be immediately transferred to the cardiac catheterization laboratory.

Patients who are stable and do not have ST elevation can receive a more conservative imaging approach. Those who have chest pain but no ischemic changes on their ECGs and an initially negative finding on their troponin biomarker can undergo resting SPECT, which is effective in diagnosing heart disease in women. In general, patients who have normal ECG results and negative troponin levels are at low risk for acute coronary events, and clinicians are encouraged to weigh imaging risks against benefits, sometimes choosing not to use routine imaging in the emergency setting.

Special Considerations for Technologists
Radiation safety is of concern for all radiologic technologists when conducting medical diagnostic imaging that uses ionizing radiation on any patient. In particular, CCTA and cardiac catheterization procedures can involve high levels of radiation. Technologists and other radiology personnel who provide diagnostic medical imaging services and care to women with suspected heart disease need to consider certain factors with regard to radiation, pregnancy, and other biological factors.

Radiation Effects in Women
Deterministic effects from radiation are those that occur when a certain tissue receives absorbed dose above a specific threshold. Examples of deterministic effects are skin erythema and epilation. Direct cardiac toxicity also is possible. Stochastic effects are more long term in nature and eventually can result in malignancy. Radiology professionals, particularly those who work in catheterization labs and with CCTA, must consider radiation effects and potential pregnancy in any female patient of childbearing age, along with characteristics of radiation effects in women. For example, stochastic radiation effects decrease with age for men and women.
but always are slightly higher in women. Studies have demonstrated significant variation in radiation dose for key cardiac examinations such as CCTA and nuclear imaging. Technological advancements have helped lower dose, but additional steps should be taken to ensure ALARA (as low as reasonably achievable) principles are met and equipment is properly operated. Professional societies and regulatory agencies are working with vendors and industry leaders on improved methods to estimate and record effective dose from cardiovascular imaging examinations and therapeutic procedures.

**Pregnancy**

Heart disease is the leading cause of death during pregnancy other than obstetric-related causes. Several cardiovascular changes take place in a pregnant woman’s body, including increased cardiac output and peripheral vascular resistance. Other changes, such as myocardial and left ventricular function, have not specifically been described. The physiological process of pregnancy results in progressive left ventricular remodeling, and postdelivery hemodynamic and morphological changes can take up to 6 months to return to normal.

Radiation injury to the fetus is a risk among pregnant patients. Ordering physicians and radiologists must work with pregnant women to balance the need for certain information that can be obtained from diagnostic medical imaging methods that use ionizing radiation with potential risks. Pregnant women usually are cautioned to postpone elective procedures involving radiation, particularly when they are in the first trimester of their pregnancy. The technologist plays a critical role as the person in the radiology department most likely to communicate with the patient about the possibility she may be pregnant.

**Breast Tissue**

An Institute of Medicine report stated that medical imaging is the leading environmental cause of breast cancer. Every diagnostic imaging department and cardiac catheterization laboratory should adhere to a standard radiation safety program that emphasizes ALARA principles for all patients and procedures. Patients should be adequately protected during examinations and catheterization procedures with appropriate technique and shielding.

CCTA usually includes most of a woman’s breast tissue within the examination scan range. The protocol for CCTA uses a limited z-axis coverage that images only the mid to lower portion of the patient’s thorax. Shielding has been shown to reduce scatter radiation, but the breasts also can be displaced cranially outside the beam range to reduce exposure to breast tissue and improve CCTA image quality. One group of researchers investigated a method for displacing the breasts outside of the scan range and shielding the breast surface to determine effects of the technique on image quality and dose (see Figure 2).

The authors divided a group of women undergoing CCTA into 3 subgroups. One group received breast displacement, the second received displacement and breast shielding, and the third was a control group. The authors analyzed the data and found that most of the women (79%) in the displacement groups had good or excellent breast displacement, but the technique was less effective on women with smaller breasts (A cup), as measured by self-reported cup size. The group of women who had their breasts displaced received a 23% reduction in dose to the breast surface as measured by thermoluminescent dosimeters placed on each breast quadrant and the areolar region of each breast. Those who had displacement and shielding showed a 36% dose reduction, and no significant difference in image quality was detected among groups, although glandular breast tissue was largely removed from the scan range (see Figure 3).

All staff involved in fluoroscopically guided procedures should wear adequate shielding, and female staff should ensure that their lead aprons fit in such a way that they adequately protect the workers’ breast tissue and axilla.

**Devices and Medications**

As a population, women who have revascularization procedures are older than men who have the procedures because of differences in the clinical manifestations of CAD. They also tend to be physically smaller and have more severe angina and more comorbidities at the time of catheterization. Women who undergo endovascular repair of abdominal aortic aneurysms fare better than those who have open surgical procedures to repair their aneurysms but still have higher complication rates and mortality than men who have the procedures. One explanation could be that women usually have smaller femoral and iliac arteries, which complicates or makes...
impossible the passage of endovascular devices. The neck of the aorta must be evaluated to ensure that it is long enough and large enough in diameter to accommodate placement of an endovascular device. For example, the aortic neck cannot be blocked by calcifications, thrombi, or tortuosity.3

Although some advances have improved outcomes for women undergoing percutaneous coronary interventions, others likely added to complications in women. Intervventional devices such as rotablation, directional coronary atherectomy, and laser therapy appeared to add to complications in female patients more than in male patients. Atherectomy uses larger sheaths and guiding catheters, increasing risk of complications in peripheral vasculature and coronary arteries in women’s smaller vessels. More perforations have been recorded in women, particularly those with diabetes, than in men from laser procedures. Smaller sheaths and weight-adjusted heparin doses now are more commonplace as interventional techniques for women have progressed.28

Women’s different physiologic makeup influences device effectiveness and can cause differences in reactions to or effectiveness of medications. For example, women tend to have lower serum potassium levels than men. Factors such as serum potassium and hormone levels can affect heart rhythm control.3

Age and sex have been found to affect contrast-induced acute renal injury. Because women are smaller, typically older when having CVD interventions, and are more likely than men to have renal impairment, they also are more inclined to react to equivalent male doses of anticoagulant therapies, resulting in bleeding problems. They also might receive excessive doses of contrast agents, which could result in contrast-induced nephropathy. Technologists should be aware of these issues when injecting contrast in women older than aged 65 years.3,9

Bleeding Complications

Improvements in percutaneous coronary intervention techniques and advancements such as use of vascular closure devices, smaller sheaths, and better access techniques and antithrombotic approaches have reduced overall complication rates. Still, women have higher risks of bleeding and vascular complications from these procedures. Ahmed et al evaluated more than 13 000 cases involving women and 32 000 involving men to
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compare vascular complication rates and determine risk factors that led to bleeding complications.\(^4\)

Even with improvement in technique and regimens to control bleeding during percutaneous coronary interventions, women continue to have more bleeding complications than do men. One explanation is excess dosing with platelet receptor antagonists. Most bleeding and vascular complications probably are caused by women’s smaller and stiffer vasculature.\(^4\)

Ahmed et al found that although bleeding from percutaneous coronary interventions had declined in women over the 6-year period from 2002 through 2007, women still had a greater than twofold risk of bleeding or vascular complication compared with men. They also determined that women who are older, have lower BMIs, and have comorbidities such as renal or congestive heart failure are more likely to have vascular complications. Risk was lowered by use of smaller sheaths and improved sheath management following procedures. The authors noted that patients who experienced bleeding or vascular complications were significantly more at risk of major adverse cardiac events such as stroke, MI, or death.\(^4\)

Humphries et al investigated older (> 76 years) high-risk patients who underwent transcatheter aortic valve replacement at 2 Canadian hospitals and found that women had better short-term and long-term survival following the procedure.\(^5\) This was in spite of a higher rate of vascular complications in the female patients, including major life-threatening bleeding events.\(^5\)

As a rule, women being evaluated for acute coronary events often are older than men who are and have more comorbidities that could lead to complications or death from invasive procedures. Hypertension, hyperlipidemia, diabetes, and heart failure are among common comorbidities.\(^7\) Because women tend to have more bleeding complications, physicians and patients can be more reluctant to use warfarin anticoagulation. Providers should discuss the risks, benefits, and alternatives with patients when bleeding or thromboembolism is concerns for cardiac imaging and therapeutic procedures.\(^1\)

**Quality of Life**

In a 2008 report on women’s health research, the Institute of Medicine stated that although there has been progress toward reducing mortality from CVD in

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**Figure 3.** This 48-year-old woman with chest pain was part of the breast-displacement-alone group, with C-cup breasts. A. CT topogram shows that with the addition of the breast displacement device, most breast tissue has been displaced cranially outside the scan range (dashed lines). B. Axial CT image at level of origin of left main coronary artery shows the breast displacement device around the chest wall (arrows) and resultant absence of glandular breast tissue from scan range. Reprinted with permission from Foley SJ, McEntee MF, Achenbach S, Brennan PC, Rainford LS, Dodd JD. Breast surface radiation dose during coronary CT angiography: reduction by breast displacement and lead shielding. AJR Am J Roentgenol. 2011;197(2):369.
women, researchers needed to focus more on quality-of-life issues for women with heart disease. For example, enhancing wellness to prevent disease, improving functionality and mobility, and addressing disparities in care and disease burden could improve women’s health and lives. Quality of life also is an emphasis of the Joint Commission, particularly regarding patient education that can improve outcomes.

Women who have coronary heart disease have worse outcomes than do men in many clinical settings, including almost double the morbidity and mortality of men with angina. The poorer clinical outcomes experienced by women following chest pain and an acute event worsen with age.

Further, women younger than aged 50 years who have MIs have twice the mortality of men, although the gap has narrowed in recent years. The operative mortality for women who have coronary artery bypass graft surgery is double that of men. Despite higher risk of bleeding complications from percutaneous coronary interventions, women appear to have angiographic and clinical improvement that is comparable to that of men.

A study evaluating 101 patients with atrial fibrillation found that employment status and female sex were among significant factors relating to quality of life 6 months following initial treatment. Research has continued to address disparities in outcome and burden of heart disease between men and women. Women who have been assigned to rhythm control for atrial fibrillation have had 3 times the risk of cardiac events compared with male counterparts. Women tended to have congestive heart failure, thromboembolic complications, and severe adverse events from antiarrhythmic medications more often than men. In fact, adverse effects such as palpitations and fatigue often offset the positive effects of the drugs on the patients’ heart rhythms.

Up to 25% of women with angina pectoris have reported symptoms of clinical depression before reporting for cardiac rehabilitation, and depression is more common in general among women with heart disease. There are significant differences between the sexes in how they react to and cope with disease. Women often lack the social support and integration that help people with CVD cope with the physical and social stressors of their disease, yet women also tend to be more aware of their symptoms and illnesses than men. Women and men experience psychosocial barriers to care differently as well. All patients who have acute coronary syndrome tend to have major depressive symptoms, but they are more prevalent in women. A significant gap remains in the understanding of gender roles, reporting and perception of symptoms, and social issues among health-related quality-of-life measures. Often, when researchers study socioeconomic factors relating to health, they consider issues such as occupation and income but neglect to include gender roles. When gender differences are addressed, women consistently appear to have higher anxiety and stress. Norris et al suggested use of the Hospital Anxiety and Depression Scale as a screening instrument to accurately measure anxiety in women with CAD, along with depression among men with the disease.

Sleep disturbances and adverse effects from medication can cause a great deal of anxiety for women, as can fear regarding their disease. Further research also can help explain the complex relationships of such socioeconomic factors as income, race or ethnicity, and sex on quality of life for women with heart disease.

Prevention

The goal of primary CVD prevention is to help women avoid developing heart diseases by promoting healthy habits. Efforts such as the American Heart Association’s Go Red For Women campaign are aimed at awareness, education, and prevention of heart disease in women. Women must heed the advice of education programs to recognize how heart disease affects them specifically and understand risk factors they have in common with men but can affect the sexes differently. Changing behaviors such as salt intake and tobacco use and improving physical exercise and fitness are excellent steps toward CVD prevention.

Secondary prevention includes the identification and treatment of women with established heart disease or those at very high risk and the rehabilitation of women who have already had a heart attack to prevent a second attack. These preventive measures likely are more individualized than general prevention measures.
and can include quitting smoking, controlling hypertension, managing metabolic syndrome or diabetes, or managing stress, and time to better adhere to wellness and physician visits. The incidence of young women who have MIs might be low, but mortality is very high among young women with family history of heart attack who have an MI. This is an area in need of improved primary prevention.

Pharmacologic interventions also might be used to help prevent CVD in women depending on their risk level and contraindications. These can include the use of beta-blockers, warfarin, statins to lower cholesterol, or the use of aspirin. Aspirin use to prevent incidence or death from MI in women still generally is recommended only for women at highest risk. The Women’s Health Study found that low-dose aspirin (100 mg on alternate days) did not reduce incidence of nonfatal MI or cardiovascular death in women older than 45 years but reduced stroke risk. Aspirin had more effect in reducing risk of nonfatal MI in women older than 65 years but increased incidence of severe gastrointestinal bleeding. Women are less likely to be discharged from the hospital with a prescription to take aspirin following an acute coronary event than men are.

Conclusion

Although it took several decades to include women in research about CVD, the results of the work are increasing attention to sex differences in cardiovascular disease prevention, diagnosis, and management. Evidence-based therapies highlighting important sex differences in pathophysiology and clinical presentation of heart disease contributed to the marked improvements already noted in CVD survival rates among women. Further investigation is needed to continue to establish the differences between risk of heart disease for men and women and to eliminate disparities in prevention, care, and outcomes. Keeping sex and gender role differences in mind when caring for women at risk for heart disease or who have heart disease can improve quality of life and outcomes for female patients.

A more strategic approach to understanding and promoting awareness of CVD in women has evolved. Continued emphasis on sex-specific clinical research and improved application of the knowledge gained in clinical practice offers a promising future for women at risk for heart disease.

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References


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1. Between 2000 and 2007, women’s mortality from cardiovascular disease (CVD) in the United States:
   a. increased slightly.
   b. doubled.
   c. held steady.
   d. declined.

2. Many of the differences between vasculature of men and women can be attributed to:
   a. pharmacokinetics.
   b. barriers to care.
   c. female sex hormones.
   d. male sex hormones.

3. Which of the following cardiovascular abnormalities are more common in women?
   1. migraine headaches
   2. hypertension
   3. Raynaud phenomenon
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

4. Which of the following statements is true regarding women and plaque?
   a. Women have fewer risk factors for atherosclerosis.
   b. Plaque erosion is more common in women.
   c. Plaque rupture is more common in women.
   d. Women harbor more plaque than men.

5. Women have a higher risk of peripheral artery disease than men.
   a. true
   b. false

6. Which of the following risk factors for myocardial infarction (MI) has a much stronger association for women?
   a. diabetes
   b. obesity
   c. hypertension
   d. alcohol intake
7. Women tend to have congestive heart failure more often than men because of:
   1. the steeper relationship of blood pressure to blood volume.
   2. more diastolic dysfunction.
   3. poorer left ventricular function.

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

8. ______ is an infrequent cause of acute coronary syndrome with uncertain origin or clinical features that can affect young women in peripartum or postpartum states.
   a. Arrhythmia
   b. MI
   c. Spontaneous coronary artery dissection
   d. Ischemic stroke

9. Which of the following is not among signs and symptoms that classify women as high risk for CVD?
   a. abdominal aortic aneurysm
   b. metabolic syndrome
   c. diabetes
   d. chronic or end-stage kidney disease

10. ______ is such a significant risk factor for CVD that it is considered a “cardiovascular disease equivalent.”
    a. Obesity
    b. Alcoholism
    c. Diabetes
    d. Depression

11. In a study by Sundell et al, women with angina tended to have higher ______ levels.
    a. anxiety
    b. blood pressure
    c. obesity
    d. pulse

12. A 1997 American Heart Association survey found that ______ % of women reported CVD as the disease with the most health and mortality risk.
    a. 7
    b. 12
    c. 17
    d. 32

13. The bulk of evidence supporting management of heart failure historically has come from trials involving men and a predominance of:
    a. whites and Asians.
    b. invasive treatment methods.
    c. left ventricular systolic dysfunction.
    d. diastolic dysfunction.

14. Which of the following is true regarding primary care physicians and cardiac risk prevention services?
    a. Nearly all primary care physicians have helped patients stop smoking by offering quit dates.
    b. Patient reports of weight loss advice conflict with those of physicians.
    c. Physicians report that they never discuss diet and exercise with women.
    d. More than half of patients report receiving weight loss advice from their physicians.

15. In a survey regarding reasons why women fail to receive their annual visits to manage coronary heart disease, ______ was the most common practical barrier cited by women.
    a. denial regarding their heart problem
    b. fear regarding their disease
    c. having to call to make the appointment
    d. tending to care for others instead of themselves
16. Women share some symptoms of CVD and MI with men but are more likely to have:
   1. sweating.
   2. fatigue.
   3. gastrointestinal symptoms.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

17. Women benefit significantly from invasive interventions when they have _______ cardiac biomarkers.
   a. negative
   b. positive
   c. positive or negative
   d. neither positive nor negative

18. A value of chest radiography following electrocardiogram (ECG) for unstable angina is to:
   a. measure blood flow.
   b. determine heart function.
   c. exclude other causes of chest pain.
   d. provide a definitive diagnosis of MI.

19. Which of the following statements is true regarding coronary computed tomography angiography (CCTA)?
   a. CCTA is absolutely contraindicated in women.
   b. The dose from CCTA is lower than for a chest radiograph.
   c. There is no evidence that CCTA can target patients at high risk and in need of intervention.
   d. CCTA can deliver high radiation dose to women’s breasts.

20. American College of Radiology appropriateness criteria suggest _______ at rest and under stress and coronary arteriography as the highest-rated imaging methods for acute pain suggestive of coronary syndrome.
   a. ultrasonography
   b. ECG
   c. single-photon emission computed tomography myocardial perfusion imaging
   d. magnetic resonance angiography

21. Skin erythema and epilation are examples of:
   a. stochastic radiation effects.
   b. deterministic radiation effects.
   c. medication reactions unique to women.
   d. symptoms of diabetes.

22. _______ is the leading cause of death during pregnancy other than obstetric-related causes.
   a. Radiation overdose
   b. Heart disease
   c. Anesthesia overdose
   d. Motor vehicle trauma

23. Women are more likely to receive excess doses of anticoagulant therapies, resulting in bleeding problems, because of which of the following reasons?
   1. Women are smaller.
   2. Women typically are older than men when having CVD interventions.
   3. Renal impairment is more common in women having CVD interventions.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

continued on next page
24. A study evaluating 101 patients with atrial fibrillation found that employment status and female sex were among significant factors related to:
   a. short-term survival.
   b. long-term survival.
   c. complication rates immediately following treatment.
   d. quality of life 6 months after treatment.

25. The Women’s Health Study found that low-dose aspirin (100 mg on alternate days) reduced the risk of:
   a. cardiovascular death.
   b. stroke.
   c. nonfatal MI.
   d. all of the above.
Directed Reading Evaluation
Women and Heart Disease

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   - 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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No Photocopies Accepted
By all accounts, William Stewart Halsted (1852-1922) was a brilliant surgeon. Educated at Yale University and Columbia University College of Physicians and Surgeons, he also studied with leading surgeons in Europe. Known as the “father of modern surgery,” Halsted pioneered techniques for repairing inguinal hernias, ligating the subclavian artery, and performing radical mastectomy in patients with breast cancer. He is credited with developing the first surgical gloves and was an early advocate for surgical principles taken for granted today, such as controlling bleeding and handling body tissues gently during surgery. Halsted published more than 20 scientific articles during his career and founded the surgical training program at Johns Hopkins University in Baltimore, Maryland, which became a model for the nation.

In the 1880s, Halsted and some of his colleagues experimented with cocaine hydrochloride as a possible anesthetic, and Halsted soon became addicted. His experiments led to the development of neuro-regional anesthesia, but despite repeated attempts to treat his cocaine addiction, he reportedly never recovered. Later in life, Halsted also was addicted to morphine and alcohol. He seems to have hidden his addictions from others fairly well. As one colleague observed:

The proneness to seclusion, the slight peculiarities amounting to eccentricities at times...were the only outward traces of the daily battle through which this brave fellow lived for years.

Even so, drug and alcohol dependency certainly disrupted Halsted’s career, sometimes for months at a time. Although Halsted might have been one of the earliest and more noteworthy...
health care professionals with a documented substance dependency, he is by no means alone. Estimates vary, but according to the Substance Abuse and Mental Health Services Administration, about 8% of the population has a substance abuse problem. In addition, the American Nurses Association estimated that between 6% and 8% of nurses use substances to such an extent that their work is impaired, with possible consequences for themselves, their careers, and their patients. Although little recent research exists about substance use disorders among radiologic technologists, similar rates of abuse are likely among this group.

**Defining Recreational Use, Abuse, and Addiction**

Many terms describe the use of substances that can be addictive, including recreational use, social use, experimental use, risky use, misuse, abuse, excessive use, dependence, and addiction. Sometimes the terms overlap or are used imprecisely, causing confusion and misunderstanding.

Substance abuse is use that “results in adverse social and professional consequences.” These consequences might include failure to meet one’s obligations, legal problems, or conflicts with others. According to *The Diagnostic and Statistical Manual of Mental Disorders*, substance abuse is present when at least 1 of the following symptoms occurs during a 1-year period:

- Repeated failure to fulfill obligations, which might result in missing work or school, suspension or dismissal from school or work, or child neglect.
- Using substances under dangerous conditions (e.g., driving or operating machinery).
- Arrests or other legal problems connected to substance use.
- Ongoing substance use regardless of negative consequences.

Abuse is distinguished from recreational or social use, which “does not cause problems for the user” or other people, although it could at times be excessive. Abuse also is distinguished from addiction, which is sometimes known as substance dependence. Addiction is “a chronic, often relapsing brain disease that causes compulsive drug seeking and use, despite harmful consequences.” Addiction “manifests as physiologic and behavioral symptoms related to a maladaptive pattern of substance abuse.” These symptoms can include cravings for the substance, withdrawal symptoms when substance use suddenly stops, a need for increasing amounts of the substance, and spending too much time on substance use activities. Substance abuse can progress to addiction but does not always do so. Both abuse and addiction are considered substance use disorders. In addition, both are “chronic diseases that are amenable to treatment, but relapses and exacerbations can occur, particularly without appropriate therapy and follow-up care.”

Abuse and addiction are distinguished from another category on the substance use continuum: “risky use.” For example, risky use of alcohol is considered drinking more than the U.S. Department of Agriculture Dietary Guidelines for safe alcohol use. Under these guidelines, safe alcoholic consumption is “no more than one drink a day for women, no more than two drinks a day for men,” and no alcohol for individuals in certain subgroups, such as pregnant women, people taking medications that interact with alcohol, and those who plan to drive or operate heavy machinery.

The 2010 National Survey on Drug Use and Health categorized the U.S. population aged 12 years and older according to a substance use continuum that ranged from “never used” to “addiction” for substances including tobacco, alcohol, illicit drugs, and prescription drugs (see Box 1). Baldiesser reported that 10% to 15% of all physicians, psychiatrists have the highest rates of substance abuse. Anesthesiologists and solo-practice physicians also have higher-than-average rates. Radiologists are less likely to abuse substances. In the nursing profession, emergency department nurses, oncology nurses, and psychiatric nurses are more likely to abuse substances than their colleagues who work in specialties such as women’s health, pediatrics, or general practice.

**Commonly Abused Drugs**

For the purposes of this article, abused substances include alcohol, prescription drugs, over-the-counter medications, and illicit drugs. Certainly nicotine is a highly addictive substance with potentially devastating...
health effects, but because it does not impair one’s professional judgment, immediately interfere with the ability to perform job-related duties, or lead to some of the other problems typically associated with substance abuse (eg, legal problems or impaired ability to drive), it is excluded from this article.

The U.S. Drug Enforcement Administration maintains a list of monitored substances that is published annually. The listed substances are divided into 5 schedules based on “whether they have a currently accepted medical use in treatment in the United States, their relative abuse potential, and likelihood of causing dependence when abused.”

Schedule I drugs have a high potential for abuse. They require greater storage security and have a quota on manufacturing, among other restrictions. Schedule I drugs are available for research only and have no approved medical use.

Schedule II drugs also have a high potential for abuse. They require greater storage security and have a quota on manufacturing, among other restrictions. Schedule II drugs are available only by prescription (nonrefillable) and require a form for ordering.

Schedule III drugs are available by prescription, may have 5 refills in 6 months, and may be ordered orally. They have less potential for abuse than Schedule I and II substances, but abuse might lead to moderate to low physical dependence or high psychological dependence.

Schedule IV drugs are available by prescription, may have 5 refills in 6 months, and may be ordered orally. They have low potential for abuse compared with Schedule III substances.

Schedule V drugs are available over the counter. Although health care professionals are believed to abuse substances at rates similar to the general public, they tend to choose different substances than the public. Baldisseri reported that health care workers are more likely to abuse benzodiazepines and opiates and less likely to abuse marijuana and cocaine. In addition, opioids are the drugs most commonly diverted from health care workplaces. (Opioids and opiates are both narcotic analgesics. Opiates are naturally derived, whereas opioids are at least partly synthetic. Sometimes the terms are used interchangeably.) In general, substances abused by health care professionals fall into 4 categories:

- Sedatives – sometimes used for stress relief or to promote sleep. Common examples include barbiturates, benzodiazepines, methaqualone, meprobamate, and glutethimide.
- Analgesics and opiates – pain-controlling drugs such as morphine, codeine, oxycodone, hydrocodone, and propofol.
- Stimulants – less physically addictive than analgesics but associated with emotional dependence. They increase alertness and activity levels and include cocaine, dl-amphetamine, and crystal methamphetamine.
- Hallucinogens – some examples include lysergic acid diethylamide (LSD), phencyclidine (PCP), ketamine, and mescaline.

The Table presents the most commonly abused prescription drugs, along with their intoxicating effects and health consequences. According to a report from the National Center on Addiction and Substance Abuse at Columbia University, many individuals who are addicted to or are risky users of one substance also use or abuse another substance. For example, 55.7% of people with a substance addiction qualified as risky users of a second substance, and 17.3% were addicted to multiple substances.

<table>
<thead>
<tr>
<th>Substance Use Continuum in the United States</th>
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<tbody>
<tr>
<td>12.7% never used.</td>
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<tr>
<td>25.2% have no current use.</td>
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<tr>
<td>14.5% have nonrisky use.</td>
</tr>
<tr>
<td>31.7% have risky use.</td>
</tr>
<tr>
<td>15.9% have an addiction.</td>
</tr>
</tbody>
</table>

*Includes alcohol, tobacco, illicit drugs, and misuse of controlled prescription drugs.

### Historical Snapshot of Substance Use Among R.T.s

Little current research exists specifically about radiologic technologists and substance abuse, but a study published in Radiologic Technology in 1998 examined alcohol and drug use among registered technologists (R.T.s) in the mid-1990s. In August 1995, 2500 randomly selected members of the American Society of Radiologic Technologists (ASRT) were mailed questionnaires that included 42 Likert scale questions about...
### Commonly Abused Prescription Drugs

#### Table: Commonly Abused Prescription Drugs

<table>
<thead>
<tr>
<th>Name</th>
<th>Examples of Commercial Names</th>
<th>Street Names</th>
<th>DEA Schedule</th>
<th>How Administered</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depressants</strong></td>
<td></td>
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<tr>
<td>barbiturates</td>
<td>Amytal, Nembutal, Seconal, phenobarbital</td>
<td>barbs, reds, red birds, phennies, tooies, yellows, yellow jackets</td>
<td>II, III, V</td>
<td>injected, swallowed</td>
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<tr>
<td>benzodiazepines</td>
<td>Ativan, Halcion, Librium, Valium, Xanax</td>
<td>candy, downers, sleeping pills, tranks</td>
<td>IV</td>
<td>swallowed</td>
</tr>
<tr>
<td>sleep medications</td>
<td>Ambien, Sonata, Lunesta</td>
<td>forget-me pill, Mexican Valium, R2, Roche, roofies, roofinol, rope, rophies</td>
<td>IV</td>
<td>swallowed, snorted</td>
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</tbody>
</table>

**Intoxication Effects** – sedation or drowsiness, reduced anxiety, feelings of well-being, lowered inhibitions, slurred speech, poor concentration, confusion, dizziness, and impaired coordination and memory. Additional effects for barbiturates include euphoria, unusual excitement, fever, irritability, and life-threatening withdrawal in chronic users.

**Potential Health Consequences** – lowered blood pressure, slowed breathing, tolerance, withdrawal, and addiction; increased risk of respiratory distress and death when combined with alcohol.

<table>
<thead>
<tr>
<th>Name</th>
<th>Examples of Commercial Names</th>
<th>Street Names</th>
<th>DEA Schedule</th>
<th>How Administered</th>
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</thead>
<tbody>
<tr>
<td><strong>Opioids and Morphine Derivatives</strong></td>
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<tr>
<td>codeine</td>
<td>Empirin with codeine, Fiorinal with codeine, Robitussin A-C, Tylenol with codeine</td>
<td>Captain Cody, Cody, schoolboy; (with glutethimide: doors &amp; fours, loads, pancakes and syrup)</td>
<td>II, III, V</td>
<td>injected, swallowed</td>
</tr>
<tr>
<td>morphine</td>
<td>Roxanol, Duramorph</td>
<td>M, Miss Emma, monkey, white stuff</td>
<td>IV</td>
<td>injected, swallowed, smoked</td>
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<tr>
<td>methadone</td>
<td>Methadose, Dolophine</td>
<td>fizzes, amidone, (with MDMA: chocolate chip cookies)</td>
<td>IV</td>
<td>swallowed, injected</td>
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<tr>
<td>fentanyl and fentanyl analogs</td>
<td>Actiq, Duragesic, Sublimaze</td>
<td>Apache, China girl, China white, dance fever, friend, goodfella, jackpot, murder 8, TNT, Tango and Cash</td>
<td>injected, smoked, snorted</td>
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<tr>
<td>oxycodone HCL, hydrocodone bitartrate hydrromphone, oxymorphone, meperidine, propoxyphene</td>
<td>Tylox, Oxycontin, Percodan, Percocet; Vicodin, Lortab, Lorcor; Dilaudid; Opana, Numporphan, Numorphine; Demerol, meperidine hydrochloride; Darvon, Darvocet</td>
<td>Oxy, O.C., oxycotton, oxycet, hillbilly heroin, percs; Vike, Watson-387; juice, smack, D, footballs, dillies; biscuits, blue heaven, blues, Mrs O, octagons, stop signs, O bomb; demmies, pain killer</td>
<td>chewed, swallowed, snorted, injected, suppositories</td>
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**Intoxication Effects** – pain relief, euphoria, drowsiness, sedation, weakness, dizziness, nausea, impaired coordination, confusion, dry mouth, itching, sweating, clammy skin, and constipation. Fentanyl is an 80-100 times more potent analgesic than morphine. Oxycodone is used for muscle relaxation and is an analgesic twice as potent as morphine (high abuse potential). Codeine offers less analgesia, sedation, and respiratory depression than morphine. Methadone is used to treat opioid addiction and pain; significant overdose risk when used improperly.

**Potential Health Consequences** – slowed or arrested breathing, lowered pulse and blood pressure, tolerance, addiction, unconsciousness, coma, and death; risk of death increased when combined with alcohol or other central nervous system depressants. Taking drugs by injection can increase the risk of infection through needle contamination with staphylococci, HIV, hepatitis, and other organisms. Injection is a more common practice for opioids, but risks apply to any medication taken by injection.
their alcohol consumption patterns, alcohol-related behaviors, attitudes toward drinking, and drug use. Of the 912 returned surveys, most of the respondents were white (88%), women (78%), certified in radiography (92%), certificate or associate-degree holders (81%), and employed in a hospital (60%), mirroring the radiologic technology profession as a whole.

Survey results suggested that only small percentages of respondents abused either alcohol or drugs. About one-quarter reported drinking no alcohol, and most of the rest were nonrisky, occasional recreational drinkers, with two-thirds consuming no alcohol in a typical week and 47% having only 1 or 2 drinks on occasions when they did drink. However, 7% reported binge drinking behavior (ie, having 4 or more drinks on occasions when they drank), and 8% reported drinking 4 or more days per week. Based on this data, the study’s authors inferred that 3% to 4% of R.T.s may have had an alcohol abuse problem, a range that approximated estimates for alcohol abuse in other health care professions. The numbers of respondents who indicated drug use were smaller: 5% said they used tranquilizers or mood elevators, 3% admitted to using marijuana at least occasionally, 1% used stimulants, and less than 1% used opiates. However, the survey results were self-reported, and as the researchers noted, “few individuals are willing to admit the use of illegal drugs.” Thus, the actual numbers of drug users likely were higher.

In concluding their study, the authors advocated incorporating substance abuse awareness and prevention in radiologic technology educational programs. In addition, they suggested that professional organizations should learn more about identifying and helping radiologic technologists with substance abuse and addiction problems. Finally, they urged adoption of an ASRT position statement that reflected the following notions:

- Radiologic technologists are not immune from the negative effects of substance abuse.
- The ASRT recognizes that chemical substance use may lead to abuse or dependency.

Find a list of other commonly abused drugs in the online version of this article.
Substance abuse or dependency is a disease and not a moral imperfection.

The ASRT espouses an educational and therapeutic philosophy toward substance abuse. Although the ASRT does not have a position statement that captures the report’s recommendations regarding substance use, the American Registry of Radiologic Technologists (ARRT) Standards of Ethics explicitly address substance use among R.T.s and candidates for certification.

Causes of Abuse and Addiction

The precipitating factors for abuse and dependency can be grouped into 3 main areas: biological predisposition, psychological issues, and occupational factors.

Biological Factors

Substance abuse and addiction clearly have a genetic component. In fact, genetics is believed to account for 50% of addiction to alcohol. Addiction to cocaine and opioids also is likely to be heritable, although not to the same extent as alcohol addiction. In general, “when exposed to addictive substances, a genetically susceptible person is more likely to develop a pattern of dependency than someone who is not genetically susceptible.”

Individual variations in the brain’s reward systems also are thought to contribute to abuse and addiction. When dopamine receptors in the brain’s nucleus accumbens are stimulated, the individual experiences pleasure. Neural pathways in the brain influence how important that pleasure is to an individual and how strongly he or she wants it. In the case of addiction, the reward becomes a high priority and various external cues can trigger a desire for it.

Age is also a key risk factor for abuse and addiction:

[T]he earlier that drug use begins, the more likely it will progress to more serious abuse, which poses a special challenge to adolescents. Because areas in their brains that govern decision making, judgment, and self-control are still developing, adolescents may be especially prone to risk-taking behaviors, including trying drugs of abuse.

Among abusers, 96% began using substances before 21 years of age.

Psychological Factors

Substance abuse and addiction often are associated with other psychological conditions, including depression, anxiety, post-traumatic stress disorder, bipolar disorder, and schizophrenia. According to some studies, those with substance use disorders often experienced some sort of trauma or abuse as children. In addition, an impulsive personality, desire for excitement, and “sensation-seeking behavior” are sometimes associated with substance abuse and addiction. Among nurses, Talbert linked “a family history of emotional impairment, alcoholism, drug use, or emotional abuse” to increased likelihood of substance abuse. Along with one’s parents and other family members, drug-using friends and acquaintances during adolescence can influence drug use and abuse.

Occupational Factors

By virtue of their jobs and working environment, health care professionals could be at higher risk than others for substance abuse and addiction. Possible occupational risk factors include high stress levels, access to drugs at work, and a sense of comfort or control regarding drugs.

Working irregular shifts, night shifts, and extra hours all contribute to work-related stress, as do difficult relationships with coworkers and caring for patients who are acutely ill or seriously injured. Health care professionals may turn to substance use as a mechanism for coping with stressful working conditions.

Although the same observations apply to radiologic technologists and other health care professionals, Talbert wrote about nurses specifically:

As staffing levels decline, workloads increase, especially with increases in acuity among hospitalized patients. Rotating shifts, working overtime, and floating to different departments contribute to stress, fatigue, and feelings of alienation; substance abuse may be a way of coping.

In her review of stress management and radiologic technologists, Romano described additional job-related stresses R.T.s might face, including a lack of professional support, lack of opportunity for advancement on the job, work overload, and role ambiguity. “When the workplace requires the radiologic technologist to take on multiple roles, he or she may become overly
stressed and distracted by multitasking,” Romano wrote. Furthermore, radiologic technologists’ job duties are constantly evolving because of technological advancements. For example, digital imaging has eliminated many tasks that were once a routine part of technologists’ day and required them to master new procedures. According to Romano, “[s]ome of these factors might be within the technologist’s power to control, and some might not. The lack of a sense of control over one’s environment often can be a source of unhealthy stress.”

Another factor is that health care professionals have more access to drugs than most other people do. Also, because of their training in pharmacology and knowledge of drugs, they may feel less vulnerable to abuse and addiction than they otherwise would. Wright described this as “an attitude of invincibility regarding self-medication and a feeling of immunity against untoward effects of medication.”

Exposure to death and dying also may influence substance abuse in health care professionals. For example, oncology nurses are twice as likely to report binge drinking as nursing colleagues who work in women’s health, pediatrics, or general practice.

Baldisseri identified similar occupational factors that might contribute to substance abuse in health care professionals, including job-related stress, long work hours, and easy access to drugs on the job. However, she added, these are probably not the most important contributors, pointing instead to psychological and personality traits. Physicians and medical students with substance abuse problems often report a family history of the disorder, emotional difficulties, and a tendency toward sensation-seeking behavior, according to Baldisseri. Physicians also may demonstrate perfectionism and a strong drive to achieve, which could factor into substance abuse and addiction.

**How Addiction Occurs**

Historically, substance abuse was sometimes seen as a moral failing or the result of insufficient willpower, and about one-third of adult Americans continue to see it this way, according to a recent survey. However, we now recognize that substance abuse modifies the brain, making it extremely difficult to stop, even when the abuser is highly motivated to quit.

Substance abuse affects the brain by changing the way that nerve cells transmit information. Chemicals in some drugs, including marijuana and heroin, mimic the brain’s natural neurotransmitters and send abnormal messages. Other drugs, such as cocaine and methamphetamine, prompt the brain to release more neurotransmitters than normal or prevent the brain from “recycling” brain chemicals as it normally would. Consequently, the brain becomes flooded with dopamine, a neurotransmitter associated with emotion and pleasure, and the user experiences a euphoric state.

Other activities, such as eating and sex, also cause the release of dopamine in the brain but in much smaller amounts than with substances such as abused drugs. In addition, substance abuse can cause an almost immediate release of dopamine, especially when the drugs are smoked or injected, and the effects may last longer. Thus, the immediate physiological response to drug use far exceeds the response associated with other activities, and substance users are strongly motivated to continue.

However, when substance use continues, the brain compensates by decreasing dopamine production or the number of dopamine receptors, thus reducing the brain’s sensitivity to dopamine (see Figure). As a result, the user derives less pleasure from a substance, as well as other activities that normally are pleasurable. To continue receiving the rewards associated with substance use, the user must use more of the substance. This effect is known as drug tolerance.

Long-term drug abuse also affects levels of glutamate, another neurotransmitter. Glutamate is involved both with rewards and with cognition. Brain images of substance abusers show changes in areas of the brain associated with learning, self-control, decision making, and judgment. Compulsive behavior, including compulsive drug seeking, is a consequence of these brain changes. Therefore, although the initial decision to begin using drugs usually is voluntary, continued use may be beyond the individual’s control without treatment and support.

**Drug Diversion Within Health Care Facilities**

Unless adequate controls are in place, it is often easy to divert drugs prescribed for patients in health care facilities. Employees might steal drugs for personal
Berge et al described several instances of drug diversion that occurred at Mayo Clinic medical centers in 2010 and 2011. One case involved a radiologic technologist who worked in an interventional radiology suite. The technologist is believed to have taken fentanyl-filled syringes, switched the needles, and self-injected the drug. The technologist is thought to then have reattached the original needles, refilled the syringes with saline solution, and returned them for later injection in patients. According to Berge et al, this process resulted in the transmission of hepatitis C from the technologist to 5 patients.

In another case, a nurse charged with administering drugs to patients undergoing colonoscopies was found to be taking syringes of fentanyl and hiding them in a secret pocket inside her uniform top. The patients received saline injections instead of fentanyl, and the nurse used the fentanyl herself.

A third instance involved an employee removing containers intended for safe disposal of used needles, syringes, and vials. Video surveillance showed the employee emptying the contents of a sharps container into a bag, which she then took with her, presumably to retrieve the residual drugs in them. The same employee also was recorded on video reaching bare-handed into a closed sharps container, with her hand scratched and bloody as she removed it from the container.

About three-quarters of drug diversion investigations at the Mayo Clinic in Rochester, Minnesota, have ended with a confession by the employee. Some reported reasons for diverting controlled substances at work include stress relief, to improve one’s job performance and attention, and self-medication.

A health care professional might divert drugs by keeping “as needed” medications for his or her own use, self-administering wasted drugs, or giving the patient a partial dose and taking the remainder. As Berge and colleagues explained:

This theft can be of unopened vials; vials or syringes that have been tampered with, resulting in either substituted or diluted dosages being administered to the patient; or residual drug left in a syringe or vial after only a fraction of the drug that has been signed out was actually administered to the patient. In addition, this theft can be of discarded syringes or ampoules that have been properly disposed of in a ‘sharps’ safety container.

To address drug diversion in its facilities, the Mayo Clinic established drug diversion response teams composed of employees from its pharmacy, security, human resources, legal, nursing, and administration departments. Any employee who suspects drug diversion can trigger a team investigation by notifying his or her supervisor. If an employee is suspected of being impaired on the job, that person is immediately removed from duty and tested for drugs. A preliminary investigation consists of a records review and interview with the suspect employee’s supervisor. Depending on the outcome of the initial investigation, additional steps may be taken, such as an interview with the employee, ongoing surveillance, additional drug testing, and notification of law enforcement agencies such as local police and the Drug Enforcement Agency. About three-quarters of drug diversion investigations at the Mayo Clinic in Rochester, Minnesota, have ended with a confession by the employee.
Effects of Substance Abuse and Drug Diversion in Health Care Facilities

Many potential harms can result from substance abuse and drug diversion by health care professionals. One of the most obvious is injury to patients, including pain and anxiety among patients who did not receive the drugs prescribed for them. For example, a surgical patient in Minnesota reportedly received only a fraction of the fentanyl prescribed for him because most of the drug was diverted by a nurse. The patient claimed to have suffered excruciating pain and was so distressed by the care he received that he reported it to the police.”

Transmission of infections from an infected health care worker to patients through contaminated syringes is another risk, with life-threatening implications in some instances. A radiologic technologist who worked in several states is accused of transmitting hepatitis C infection to at least 39 patients over a period of years as a result of diverting drugs for self-injection (see Box 2).

Substance-abusing health care workers also can be so impaired that they make serious mistakes that harm patients in a variety of other ways. For example, a surgeon impaired by drugs perforated a patient’s colon. In another case, a dermatologist using hydrocodone could not complete biopsies.

If a health care professional addicted to or abusing drugs or alcohol harms a patient and the employer failed to detect the impairment, both the employee and his or her employer might be liable under civil law. Absenteeism, poor quality of work, and the cost of diverted drugs are additional expenses to the employer, though these costs are difficult to calculate.

The R.T.’s Responsibilities Regarding Substance Abuse

R.T.s and candidates violate the ARRT Standards of Ethics when they engage in or permit “actual or potential inability to practice radiologic technology with reasonable skill and safety to patients by reason of illness; use of alcohol, drugs, chemicals, or any other materials; or as a result of any mental or physical condition” or by “violating a state or federal narcotics or controlled-substance law.”

As Reed explained in a 2011 Radiologic Technology article about ethics for the R.T., “[a]n impaired technologist does not have the capacity to make proper decisions and provide the quality care necessary to ensure a patient’s well-being. A technologist who is operating under any form of impairment should be removed immediately from patient care responsibilities.”

Reed offered the following scenario as an illustration:

Jim is invited to a Super Bowl party where alcohol and drugs are passed around. The party breaks up in the early hours of the next day. Jim starts his shift later that morning at 7:00 a.m. During the first examination, a coworker detects the smell of alcohol on Jim and reports it to the shift supervisor. Jim is removed from the procedure and sent for an alcohol and drug screening test. The results show a 0.05 blood alcohol content.

Violators of these ethical rules are subject to investigation and sanctioning by the ARRT Ethics Committee. Sanctions can include reprimand, temporary suspension of registration, or revocation of certification, among other actions. The ARRT also may pursue civil and criminal penalties, when appropriate.

Health care professionals who believe they may have a substance use problem are encouraged to discuss the matter with their personal physician, manager or supervisor, or their employee assistance program. Those who suspect a colleague may have a problem should report it to their immediate supervisor or, if the supervisor is suspected, to the head of the department. The next steps are likely to be an interview with the health professional, tests to screen for drugs and alcohol, referral for an evaluation, treatment, and an aftercare program. Most health care professionals successfully return to work after treatment is complete.

Reluctance to Report Suspected Substance Abuse

Many reasons exist for why a health care professional might hesitate to speak up or get involved in a colleague’s suspected substance abuse. For example, one might not want to cause an otherwise capable coworker to lose his or her professional certification or unnecessarily jeopardize someone else’s job or professional reputation. Some people also worry that a substance-abusing coworker could become vindictive or violent if the problem is pointed out.

According to Baldisseri, “[i]dentification of substance use and dependence in healthcare professionals is often problematic because of the code of silence.
The case of David Kwiatkowski, a radiologic technologist, demonstrates how a health care professional suspected of having a substance abuse problem can sometimes evade detection, intervention, and professional consequences for years. Kwiatkowski worked at 19 hospitals in Michigan, New York, Pennsylvania, Maryland, Arizona, Kansas, Georgia, and New Hampshire before he was arrested on drug-related charges in 2012.\textsuperscript{19} He also is accused of infecting at least 39 patients in several states with the hepatitis C virus, a potentially life-threatening infection.\textsuperscript{20}

Kwiatkowski’s legal and substance abuse problems date back to at least 2005, when he was stopped by police in Canton, Michigan, for speeding and driving erratically. A breathalyzer test showed his blood-alcohol level exceeded legal limits, and he failed a field sobriety test. Kwiatkowski pleaded guilty to driving while intoxicated, completed 6 months of probation, and paid a fine.\textsuperscript{17} Allegedly, he did not inform the American Registry of Radiologic Technologists (ARRT) of the incident.\textsuperscript{18} Also in 2005, Kwiatkowski reported to local police that some Vicodin pills and another medication had been stolen from him and requested a copy of the police report so that he could get a new prescription.\textsuperscript{19}

In August 2013, he changed his plea to guilty for all 14 indictments against him. He is expected to serve 30-40 years in prison.

In 2005, Kwiatkowski tested positive for hepatitis C, and Kwiatkowski was infected. He was arrested in July 2012, accused of stealing syringes filled with fentanyl and refilling them with saline solution for patient use. In the process, he is believed to have transmitted the infection to dozens of patients.

In 2006, he was working at the University of Michigan Hospital when a vial of fentanyl disappeared minutes after a nurse set it down. In the interim, a second nurse reportedly saw Kwiatkowski enter and exit the room where the vial had been. Police questioned Kwiatkowski about the incident, but no charges were filed, nor was the ARRT contacted.\textsuperscript{19}

In 2008, a coworker accused Kwiatkowski of stealing a syringe filled with fentanyl from an operating room at Pittsburgh Medical Center-Presbyterian.\textsuperscript{20} Drug tests reportedly showed that Kwiatkowski had fentanyl in his system, and other syringes were found in his locker and pockets. He was fired from his job, but police were not informed, and Kwiatkowski soon found another job.\textsuperscript{20}

Over the next several years, he worked as a traveling R.T. at 10 hospitals. As a writer for the Boston Globe observed, Kwiatkowski relied on the fact that “angry former employers were too harried, or legally intimidated, to try to derail his career with damning references. They simply rushed him to the exit door and searched for a new hire.”\textsuperscript{19}

In 2010, Kwiatkowski was working at the Arizona Heart Hospital in Phoenix. He had been on the job only a short time when a colleague reportedly found Kwiatkowski unconscious in a restroom stall. A syringe labeled “fentanyl” was floating in the toilet, according to the coworker. Kwiatkowski tested positive for marijuana and cocaine.\textsuperscript{20} Police were called to the scene but did not file charges against Kwiatkowski because there was no evidence against him. (He had flushed the toilet after regaining consciousness.) Hospital officials also contacted the ARRT, but the Registry dropped its investigation because of the lack of charges against Kwiatkowski.\textsuperscript{19}

In 2011 and 2012, Kwiatkowski worked in the cardiac catheterization lab at Exeter Hospital in New Hampshire, where some coworkers reportedly had concerns about him. He was shaky and sweated heavily, they said, and often went to the restroom because he felt sick, including during patient procedures. One coworker reported seeing Kwiatkowski with white foam around his mouth.\textsuperscript{19}

In May 2012, Kwiatkowski was suspended from his job pending an investigation. Multiple patients treated in the cardiac catheterization lab had recently tested positive for hepatitis C, and Kwiatkowski was infected. He was arrested in July 2012, accused of stealing syringes filled with fentanyl and refilling them with saline solution for patient use. In the process, he is believed to have transmitted hepatitis infection to dozens of patients.\textsuperscript{20}

In December 2012, he pleaded not guilty to charges of illegally obtaining drugs and tampering with a consumer product. However, in August 2013, he changed his plea to guilty for all 14 indictments against him. He is expected to serve 30-40 years in prison.

Kwiatkowski’s official sentencing takes place in December 2013, and several civil lawsuits are still pending.\textsuperscript{27}

**Box 2**

**Tracing the Trail of a Suspected Substance Abuser**

The case of David Kwiatkowski, a radiologic technologist, demonstrates how a health care professional suspected of having a substance abuse problem can sometimes evade detection, intervention, and professional consequences for years. Kwiatkowski worked at 19 hospitals in Michigan, New York, Pennsylvania, Maryland, Arizona, Kansas, Georgia, and New Hampshire before he was arrested on drug-related charges in 2012.\textsuperscript{19} He also is accused of infecting at least 39 patients in several states with the hepatitis C virus, a potentially life-threatening infection.\textsuperscript{20}

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**Among professional colleagues who hope the problem will resolve without their direct intervention.”**\textsuperscript{3} Talbert pointed out that nurses who work together often become friends, and these friendships “can be an obstacle to recognizing and addressing problematic behavior.”\textsuperscript{76}

Another possible reason for underreporting is that “[n]o one wants to be accused of ‘overreacting’ and thus may deny the problem exists until it becomes more blatantly obvious.”\textsuperscript{79} Furthermore, some health care professionals may hesitate to report substance abuse in a colleague without “solid evidence.”\textsuperscript{79}

A national survey of almost 2000 physicians’ perceptions and experiences regarding impaired and incompetent colleagues concluded that while most agreed with the professional duty to report an impaired colleague, approximately 30% did not feel prepared to deal with the situation.\textsuperscript{26} Furthermore, about one-third of respondents with “direct, personal
knowledge” of a colleague’s impairment or incompetence did not report that physician. Survey participants gave a variety of reasons for their failure to report impairment and incompetence, including the belief that “someone else was taking care of the problem,” “nothing would happen as a result of the report,” and “fear of retribution.”

Unfortunately, coworkers and supervisors sometimes enable substance use problems in other health care professionals. They might, for instance, overlook absences, assign a lighter workload, or ignore mistakes or other job-related problems. Thus, a substance abuser is sometimes protected from the consequences of his or her behavior and can continue to deny that a problem exists. 

**Detecting Substance Abuse**

Identifying health care professionals who have substance abuse problems is particularly difficult. “Healthcare professionals seem to be good at hiding signs and symptoms of substance use,” and they may even consider themselves immune to substance abuse and addiction. Furthermore, they tend to self-diagnose and self-treat substance use problems without consulting others. With opioid addiction in particular, health care professionals may continue to function relatively well on the job. On average, the time between development of an opioid abuse problem and its discovery is about 12 to 18 months. Close coworkers often are aware of substance abuse issues long before a manager or supervisor is alerted. Box 3 lists some signs that might be associated with impairment, substance abuse, and addiction in health care professionals in the workplace.

**Box 3**

**Possible Signs of Substance Impairment or Abuse in Health Care Coworkers**

- Frequent absenteeism or tardiness.
- Missing work without notice or giving implausible reasons for absences.
- Coming to work when not scheduled to be there or unnecessarily arriving early or lingering after a scheduled shift.
- Going to the restroom or stockroom frequently or for long periods.
- Spending too much time in a medication room or near a medication cart.
- Isolating oneself from coworkers (eg, changing to a late-night shift).
- Slurred speech or alcohol on the breath.
- Tremors.
- Lethargy.
- Making mistakes because of inattention or having difficulty concentrating.
- Declining work performance.
- Sloppy dress or grooming, especially when this was not a problem previously.
- Consistently wearing long sleeves, even in warm weather.
- Personality changes, especially mood swings, impulsiveness, depression, unexplained anger, or talking more or less than is usual for that person.
- Deteriorating relationships with coworkers, patients, and administrators, or complaints from others; having difficulty with people in positions of authority.
- Excessive waste of drugs or insisting on administering drugs to patients personally.

**Treatment and Recovery**

Regrettably, most people with substance addictions — about 90% — do not receive treatment, and for those who do, treatment often is inadequate. People with substance abuse and addiction problems do not seek or receive treatment for numerous reasons, including not knowing where to turn for help, lack of insurance coverage, the stigma associated with addiction, worry over privacy issues, lack of time, and insufficient treatment programs in one’s area. Furthermore, too many treatment programs offer substandard care, according to a 2012 report by the National Center on Addiction and Substance Abuse at Columbia University. The report found that most caregivers in addiction treatment programs are not medical professionals and lack the training and skills to offer appropriate care. Box 4 lists 13 principles of effective treatment from the National Institute on Drug Abuse.

The goals of treatment for substance abuse are “understanding and acceptance of the concepts of abuse and dependence, identification...of triggers that prompt abuse, development of...coping skills and lastly, continued abstinence.” Best practices in addiction treatment require:

- Comprehensive assessment – this includes a complete evaluation of the addiction and any
comorbidities, followed by treatment planning designed specifically for the individual patient.

- Stabilization – treatment begins with abstinence from the addictive substance, which might require medical detoxification.

- Acute and chronic disease management – this can include cognitive behavioral therapy provided by a qualified professional as well as pharmacologic treatment for addiction, such as the opioid antagonist naltrexone. Other drugs used to treat alcohol and drug addiction include methadone, buprenorphine, disulfiram, and acamprosate. The goal of cognitive behavioral therapy is to “help patients recognize, avoid, and cope with situations in which they are most likely to abuse drugs.”

- Because addiction is a chronic illness and patients are vulnerable to relapse, management must be ongoing. “People with serious substance abuse disorders commonly require care for months or even years,” according to Fletcher. “The short-term fix mentality partially explains why so many people go back to their old habits.”

- Support services – peer support groups, family counseling and education, legal assistance, and other types of aid might all be part of the treatment plan. Family involvement often is helpful and in some cases a necessary part of recovery. Treatment often includes participation in a support program such as Alcoholics Anonymous or Narcotics Anonymous although not everyone finds these types of programs helpful. There are also recovery support meetings specifically for health care professionals; these are called Caduceus meetings. The goal of group therapy is to help patients “face their drug abuse realistically, come to terms with its harmful consequences, and boost their motivation to stay drug free.” In addition, group therapy can show patients ways to “solve their emotional and interpersonal problems without resorting to drugs.” Random drug testing, sometimes for years after treatment begins, may be part of the recovery plan.

Perhaps most important, treatment should be individualized: “The research evidence clearly demonstrates that a one-size-fits-all approach to addiction

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**Box 4**

**13 Principles of Effective Treatment for Substance Addiction**

1. Addiction is a complex but treatable disease that affects brain function and behavior.
2. No single treatment is appropriate for everyone.
3. Treatment needs to be readily available.
4. Effective treatment attends to multiple needs of the individual, not just his or her drug abuse.
5. Remaining in treatment for an adequate period of time is critical.
6. Behavioral therapies — including individual, family, or group counseling — are the most commonly used forms of drug abuse treatment.
7. Medications are an important element of treatment for many patients, especially when combined with counseling and other behavioral therapies.
8. An individual’s treatment and services plan must be assessed continually and modified as necessary to ensure that it meets his or her changing needs.
9. Many drug-addicted individuals also have other mental disorders.
10. Medically assisted detoxification is only the first stage of addiction treatment and by itself does little to change long-term drug abuse.
11. Treatment does not need to be voluntary to be effective. Sanctions or enticements from family, employment settings, or the criminal justice system can significantly increase treatment entry, retention rates, and the ultimate success of drug treatment interventions.
12. Drug use during treatment must be monitored continuously, as lapses during treatment do occur.
13. Treatment programs should test patients for the presence of HIV/AIDS, hepatitis B and C, tuberculosis, and other infectious diseases, as well as provide targeted risk-reduction counseling, linking patients to treatment if necessary.

treatment typically is a recipe for failure.” An individualized plan should take into account the “stage and severity” of addiction, any other health problems, past treatments for addiction, and other personal factors that could affect treatment outcomes.⁷

Reported recovery rates for health care professionals with substance use disorders are highly variable, probably because of differences in treatment methods, the groups studied, and follow-up times. According to the National Center on Addiction and Substance Abuse at Columbia University, fewer than half of people who enter a formal addiction treatment program complete the program before they are discharged.⁷ Physicians reportedly have better recovery rates than the general population, and those who participate in an inpatient treatment program lasting 2 to 4 weeks also are more likely to recover successfully.⁷ Studies show that among nurses who leave the workforce because of substance impairment, between 70.2% and 97.4% eventually return to clinical practice.⁷

Most states have a physician health program to treat physicians and some other types of health professionals, such as dentists and pharmacists, who have a substance addiction or certain mental health issues.²⁹ Physicians might self-refer for these programs, but in most cases their participation is required by a licensing board, hospital, or another organization.²⁹ Program participants must complete specific steps toward recovery.²⁹ Typically, these steps include abstaining from all addictive substances, attending weekly individual psychotherapy sessions and group therapy sessions with other physicians, meeting regularly with a support group, participating in a monitoring program, and submitting to drug screening tests several times per month.³⁰ A 5-year study of 904 physicians in 16 physician health programs showed that most were abstinent during the study period: 78% had no positive screening tests for either drugs or alcohol.³⁰ In addition, 72% were practicing medicine after treatment ended.³⁰

Evaluation of a Treatment Program

Gossop and colleagues in London, England, studied a group of 62 people with drug or alcohol abuse problems referred to a new treatment program specifically for health care professionals.³¹ The group included physicians, nurses, dentists, a pharmacist, medical laboratory assistants, and operating room technicians. A majority of the patients (59%) primarily abused alcohol; among the patients who primarily abused drugs, opiates and anesthetics were the most common drugs of choice. Forty-three percent of the patients also had some type of psychological disorder, with depression being the most common disorder by far. The patients were referred to the program for a variety of reasons, including poor job performance, absenteeism, disciplinary action by their employer, and legal reasons.³¹

The treatment program consisted of a 28-day inpatient stay and outpatient follow-up supportive care for a year. During the inpatient portion, patients received psychosocial counseling provided by a psychiatrist, pharmacologic treatment for withdrawal symptoms, and educational sessions to help prevent relapse and develop coping abilities. Patients with alcohol dependencies were treated in separate units from patients with drug dependencies.³¹

Of the 62 people initially referred for treatment, only 46 actually began the program. (The remaining 16 failed to contact the service following referral.) Of those who began inpatient treatment, 24 completed the program and 22 dropped out. In 2001, Gossop et al reported that patients who used multiple substances were less likely to begin and complete inpatient treatment than single-substance users. Also, alcohol abusers were more likely to complete treatment than patients who abused other substances.³¹ No differences were noted between those who began inpatient treatment and those who did not in terms of age, sex, or profession. Long-term follow-up data are not available for this cohort of patients.

A 2012 study of people with opioid dependencies examined the reasons patients drop out of psychosocial outpatient treatment.³² This study evaluated a range of factors and determined that age was the only significant predictor for dropping out: Younger patients were more likely to discontinue outpatient treatment than older ones. The authors concluded that treatments should be tailored for the needs of younger people.³²

Relapse

Unfortunately, relapse following addiction treatment is fairly common, with 25% of health professionals in one study relapsing at least once and a smaller proportion relapsing multiple times.³³ Some of the many factors that can contribute to relapses include denial,
inadequate coping skills, isolation, complacency, family dysfunction, and failure to attend support group meetings.\textsuperscript{9} Research is providing a clearer picture of which patients are more likely to relapse and need additional monitoring.

Domino and colleagues in Washington state retrospectively evaluated a cohort of 292 health care professionals who completed substance abuse treatment programs during a 10-year period and were subsequently enrolled in a monitoring program.\textsuperscript{33} Most of the study cohort were men (84%), aged 40 years or older (72%), and physicians (82%), although other health professions also were represented. Relapse was determined through self-reports and behavioral, chemical, and workplace monitoring. The main focus of the study was to determine whether health care professionals addicted to opiates were more likely to relapse after treatment than those with other types of substance addictions (ie, alcohol, cocaine, benzodiazepines, and other drugs).\textsuperscript{33}

The researchers found that subjects addicted to a "major opioid" (ie, fentanyl, morphine, meperidine hydrochloride, methadone hydrochloride, heroin, or oxycodone hydrochloride) were in fact more likely to relapse, but only when they also had a coexisting psychiatric disorder.\textsuperscript{33} In addition, having a family history of substance abuse raised the likelihood of relapse after addiction treatment.\textsuperscript{33} Having all 3 risk factors — major opioid addiction, a coexisting psychiatric disorder, and a family history of substance abuse — raised the risk "markedly." Furthermore, the risk of relapse increased after an initial relapse.\textsuperscript{29} Domino et al concluded that health care professionals with a substance abuse problem who have 1 or more of the risk factors identified in the study or a history of relapse after addiction treatment might benefit from longer and more intensive monitoring.\textsuperscript{33}

**Prevention**

Teenagers are particularly vulnerable to developing substance abuse problems, and many preventive programs are aimed at teens. Substance abuse prevention efforts appear to be most effective when they are targeted at younger adolescents, teach skills for resisting substance use, and include follow-up sessions that reinforce initial learning.\textsuperscript{33} For example, Botvin and colleagues in New York state evaluated the long-term effectiveness of a substance abuse prevention program for seventh-, eighth-, and ninth-grade students. This randomized controlled trial involved 3597 mostly white middle-class students who were evaluated for substance use in 12th grade and had either completed the substance abuse program in middle school or were assigned to a control group that received no instruction. The program focused on 3 "gateway" drugs: tobacco, alcohol, and marijuana.\textsuperscript{34}

Rather than focusing on the long-term effects of substance abuse and addiction, the prevention program emphasized "information and skills for resisting social influences to use drugs and generic personal and social skills," such as "building self-esteem, resisting advertising pressure, managing anxiety, communicating effectively, developing personal relationships, and asserting rights."\textsuperscript{34} For instance, the students learned how to use assertiveness skills in situations where they felt pressured to use drugs. Trained presenters taught one group of students, and another group received video instruction. The program consisted of 15 classes in seventh grade, 10 "booster" sessions in eighth grade, and 5 additional booster sessions in ninth grade.\textsuperscript{34}

The researchers found significant reductions in drug use and especially “polydrug” use (ie, concurrent use of alcohol, tobacco, and marijuana) among 12th-grade students who had been in the prevention program 5 years earlier compared with students assigned to the control group.\textsuperscript{34} Among students who completed most or all of the program, there were 66% fewer users of all 3 substances and up to 44% fewer users of any substance.\textsuperscript{34} Botvin et al noted that the effects of some other prevention programs “decayed” over time, while this program demonstrated long-term effectiveness. They speculated that this was because the program included a sufficient number of initial classes plus booster sessions 1 and 2 years after the original intervention.\textsuperscript{34} Furthermore:

*The prevention program used in this study was more comprehensive than those tested in previous long-term, school-based drug abuse prevention studies. The results of this follow-up study suggest that, to be effective, drug abuse prevention approaches may need to include an emphasis on increasing general personal competence as well as teaching social resistance skills. This may be particularly important for reducing the proportion of individuals who develop more serious patterns of drug use.*\textsuperscript{34}
In addition to prevention programs aimed at middle- and high-school students, health professions educational programs could incorporate a component about coping with professional stress that addresses substance abuse and recognizing substance use problems in the workplace. Baldisseri suggested that sessions with a health professional who had him- or herself successfully recovered from a substance abuse problem could be particularly helpful for health professions students.

Finally, Lapham et al reported on an effort to prevent substance abuse by reducing binge drinking among the employees of a large managed care organization in the southwestern United States. The WISE (Workplace Initiative in Substance Education) intervention focused on relatively low-cost educational and motivational techniques. These included a 2-hour training session for managers and supervisors about substance abuse awareness and employee referral procedures, a 1-page flyer about alcohol abuse mailed to all employees, printed information and videos available in staff lounges, and brief counseling for employees who wanted it. The researchers compared health risk self-appraisal scores for employees who participated in the WISE intervention and a control group of employees who did not.

Lapham et al found no difference in the amount of binge drinking, defined as 5 or more drinks consumed on one occasion during the past 30 days, either between the 2 groups or before and after the WISE intervention in the study group. However, they reported that employees in the intervention group were 2.59 times more likely than the control group to express a desire to reduce their drinking. Lapham et al described this result as "encouraging" and noted that it suggests that the intervention ‘made an important contribution toward stimulating employees’ critical inspection of their drinking habits.’ They continued:

The finding that motivation to change was affected, while binging behavior was not, was somewhat expected within the short 2-year period of study. Because alcohol habits are interconnected with cultural norms and reinforced by social customs, altering drinking behavior in a group that was not already predisposed toward change would be difficult and would require time to progress through the stages of change.

Thus, interventions such as WISE might be more successful the longer they remain in place.

An Alcohol Abuse Vaccine?

Early in 2013, researchers in Chile began preclinical trials of a “vaccine” that might prevent alcohol abuse and addiction. The treatment induces symptoms associated with a hangover, including severe headaches and nausea, when a small amount of alcohol is consumed. Currently, the treatment’s developers are testing it on mice to determine proper dosing; human trials are expected to begin in November 2013. The treatment is not a cure-all but could be “an important first step.”

Substance Abuse and Licensure

Some state licensure boards for radiologic technologists specifically ask applicants about their history of substance use, abuse, or addiction in an effort to identify R.T.s who might have a problem that could affect their work. For example, Vermont’s licensure application form asks:

- “Does your use of alcohol, substances or prescription medications impair or limit your ability to practice this profession with reasonable skill and safety?”
- “Are you currently addicted to or in any way dependent on alcohol or habit forming drugs?”

If the answer to either question is yes, the applicant must provide a detailed written explanation. Similarly, Utah’s application for radiologic technologists licensure requires answers to the following questions:

- “Have you been terminated from a position because of drug use or abuse within the past five (5) years?”
- “Are you currently or have you recently (within the past 90 days) used any drugs (including recreational drugs) without a valid prescription, the possession or distribution of which is unlawful under the Utah Controlled Substances Act or other applicable state or federal law?”
- “Have you ever used any drugs without a valid prescription, the possession or distribution of which is unlawful under the Utah Controlled Substances Act or other applicable state or federal law, for which you have not successfully completed or are not now participating in a
supervised drug rehabilitation program or for which you have not otherwise been successfully rehabilitated?" 

An affirmative answer does not necessarily preclude licensure, but the state’s Division of Occupational and Professional Licensing may request additional documentation, if it is deemed necessary. 

**Conclusion**

Health care professionals have battled substance abuse problems at least since William Stewart Halsted’s time. Although current research about radiologic technologists’ substance use patterns is lacking, data are available about other health professionals, such as nurses. According to one estimate, between 6% and 8% of nurses use substances to the extent that their work is impaired. Health care professionals tend to abuse different substances from the population at large, with opiates and benzodiazepine abuse being more common and cocaine and marijuana abuse less common.

Biological and psychological factors predispose some individuals to substance use problems, and occupational factors also are recognized. Because of the inherently stressful nature of their jobs, health professionals might be at increased risk for substance abuse. In addition to coping with the stress of caring for critically ill and injured patients, radiologic technologists sometimes work irregular shifts and long hours. For some, exposure to death and dying is a regular part of the job. In addition, some radiologic technologists and other health professionals may have a sense of personal invincibility regarding drug use because of their education in pharmacology and exposure to drugs at work. 

Because of their training and experience, health professionals also could be skilled at hiding a substance abuse problem, making detection more difficult. They might deny having a problem or attempt to self-treat substance abuse, rather than seek help. 

The ethical rules of the radiologic technology profession absolutely prohibit an R.T. from practicing or permitting another to practice if the technologist cannot exercise reasonable skill and safety because of substance use. Yet a radiologic technologist might hesitate to report suspected substance abuse in a colleague for many reasons, including worry over possible retribution, a desire not to be seen as overreacting, and concern over that colleague’s professional future. Nevertheless, substance abuse and drug diversion in health care workplaces can have terrible consequences. Drug-diverting health care professionals cause harm to patients by withholding prescribed pain medication and transmitting potentially life-threatening infections.

Recovery from substance abuse is possible, although as with any chronic condition, recovery requires vigilance and long-term care. Statistics show that most people with substance addictions don’t get treatment, and among those who do, some do not receive care consistent with recognized best practices in addiction medicine. Treatment must be personalized and should include a complete assessment; abstinence with medical detoxification, if indicated; psychosocial therapy; pharmacologic treatment (for some patients); and a variety of supportive services. Peer support groups are helpful for many people recovering from substance addictions and sometimes attendance is limited to health care professionals. Most health care professionals who leave the workforce because of substance use issues eventually return to work.

Drug abuse prevention programs can be effective but must take place long before students enter health professions educational programs. Information about substance abuse prevention, detection, and treatment also could be incorporated into radiologic technology educational programs. In addition, some states attempt to prevent radiologic technologists with substance use problems from obtaining a professional license by asking about substance use, abuse, or addiction on licensure application forms.

By its nature, substance addiction is difficult to treat because it changes the way the brain works, affecting self-control, decision making, and judgment and causing compulsive behavior. Nevertheless, radiologic technologists should make every effort to prevent, detect, and report substance abuse in their workplaces for the sake of their patients, colleagues, employers, profession, and for themselves.

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References


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1. Who was William Stewart Halsted?
   1. the “father of modern psychiatry”
   2. developer of the surgical technique for radical mastectomy
   3. a physician addicted to cocaine and other substances

   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

2. According to the American Nurses Association, what percentage of nurses use substances to the extent that their work is impaired?
   a. less than 2
   b. 2 to 4
   c. 6 to 8
   d. more than 10

3. The 2010 National Survey on Drug Use and Health categorized _____% of Americans aged 12 years and older as “risky” users of an addictive substance.
   a. 12.7
   b. 14.5
   c. 25.2
   d. 31.7

4. Which of the following statements is true of Schedule II controlled substances?
   a. They have no approved medical uses.
   b. They have a high potential for abuse.
   c. They are available over the counter.
   d. Prescriptions may be refilled 5 times in 6 months.

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

To earn continuing education credit:
- Take this Directed Reading quiz online at www.asrt.org/drquiz.
- Or, transfer your responses to the answer sheet on Page 86 and mail to ASRT, PO Box 51870, Albuquerque, NM 87181-1870.

New and rejoining members are ineligible to take DRs from journal issues published prior to their most recent join date unless they have purchased access to the quiz from the ASRT. To purchase access to other quizzes, go to www.asrt.org/store.

Read the preceding Directed Reading and choose the answer that is most correct based on the article.
5. Which substance(s) are health care professionals more likely to abuse than the public in general?
   a. alcohol
   b. marijuana and cocaine
   c. benzodiazepines and opiates
   d. dextromethorphan

6. In which category of drugs is propofol classified?
   a. sedatives
   b. analgesics and opiates
   c. stimulants
   d. hallucinogens

7. Which of the following is not an intoxication effect of benzodiazepines?
   a. slurred speech
   b. reduced anxiety
   c. increased alertness and concentration
   d. impaired coordination

8. Which of the following is not a commercial name for the prescription drug fentanyl or its analogs?
   a. Actiq
   b. Roxanol
   c. Duragesic
   d. Sublimaze

9. In a survey of radiologic technologists and substance use conducted in the mid-1990s, 7% of respondents reported:
   a. binge drinking.
   b. occasional use of cocaine.
   c. diverting drugs in the workplace.
   d. failing to report an impaired colleague.

10. Addiction is associated with:
    1. genetic susceptibility.
    2. abstinence from addictive substances during adolescence.
    3. psychological disorders such as depression and anxiety.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

11. Which of the following occupational characteristics was not mentioned as a possible risk factor for substance abuse in some health care professionals?
    a. exposure to death and dying
    b. an attitude of invincibility regarding self-medication
    c. a sense of control over one’s work environment
    d. working irregular shifts and long hours

12. Drugs such as cocaine and methamphetamines affect the brain by:
    1. prompting the release of more neurotransmitters than normal.
    2. preventing the recycling of brain chemicals.
    3. mimicking naturally occurring neurotransmitters.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3
13. According to the article, all of the following are reasons why health care professionals divert controlled substances at work **except:**
   a. for stress relief.
   b. to improve job performance.
   c. for self-medication.
   d. to express frustration with supervisors.

14. At the Mayo Clinic, who can trigger an investigation by the drug diversion response teams?
   a. any employee who suspects drug diversion
   b. managers and supervisors
   c. physicians
   d. the director of pharmacy

15. Who might be liable under civil law if a health care professional impaired because of substance use harms a patient?
   1. other health care professionals who interacted with the patient
   2. the employer
   3. the health care professional
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

16. Under the American Registry of Radiologic Technologists (ARRT) Standards of Ethics, it is an ethical violation for a registered technologist to practice professionally if he or she is endangering a patient because of drug or alcohol use.
   a. true
   b. false

17. Which of the following might make a health care professional hesitant to report a colleague with a suspected substance abuse problem?
   1. worry that the colleague might become vindictive or violent
   2. a desire not to jeopardize the colleague’s job
   3. not wanting to be seen as overreacting
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

18. Which of the following are possible signs of substance abuse in health care professionals?
   1. coming to work when not scheduled to be there
   2. spending too much time in a medication room or near a medication cart
   3. isolating oneself from coworkers; for example, changing to a late-night shift
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

19. Best practices for addiction treatment include:
   a. comprehensive assessment, stabilization, acute and chronic disease management, and support services.
   b. comprehensive assessment, hospitalization, acute disease management, and surveillance.
   c. hospitalization, detoxification, acute disease management, and support services.
   d. detoxification, hospitalization, chronic disease management, and surveillance.
20. An individualized treatment plan for substance addiction should take into account:
   1. the patient’s other health problems.
   2. the stage and severity of the addiction.
   3. any addiction treatments the patient received in the past.
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

21. According to a study of a substance abuse treatment program for health care professionals in England, which group was more likely to complete treatment?
   a. younger patients
   b. dentists
   c. those who abused opiates
   d. those who abused alcohol

22. In the study by Domino et al, which factors were positively associated with relapse after treatment for addiction?
   1. previous relapse
   2. alcohol dependency
   3. a coexisting psychiatric disorder
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

23. In the study by Botvin et al of a school-based substance abuse prevention program, which components were credited with boosting the program’s long-term effectiveness?
   1. follow-up sessions that reinforced initial learning
   2. teaching skills for resisting pressure to use substances
   3. emphasizing the long-term health effects of substance abuse
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

24. In the study by Lapham et al of the WISE (Workplace Initiative in Substance Education) intervention, what result did the authors find?
   a. Binge drinking decreased.
   b. Alcohol consumption decreased overall.
   c. Participants reported a desire to reduce their drinking.
   d. Alcohol consumption increased overall, but binge drinking decreased.

25. State licensing boards for radiologic technologists may not ask whether an applicant has a substance abuse problem or addiction.
   a. true
   b. false
Directed Reading Evaluation
Substance Abuse and the R.T.

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

If you have comments or questions about this Directed Reading, please write them below or send them separately to Ellen Lipman, Director of Professional Development, ASRT, 15000 Central Ave SE, Albuquerque, NM 87123-3909 or elipman@asrt.org.
Substance Abuse and the Radiologic Technologist

Expires: Oct. 31, 2015
Approved for 1.5 Category A CE Credits

-- A passing score is 75% or better.
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Identification Section

We need your Social Security number to track your CE credits. Please fill in your SSN in the boxes on top, then fill in the circle corresponding to each number under the box. The circles must be filled in accurately.

Member Information Section

To ensure proper credit please PRINT the following information.

Name ____________________________
Address __________________________
City ______________________________
State ________ ZIP _____________
Work Phone ________________________
Home Phone ________________________

CE Answers Section

USE A BLUE OR BLACK INK PEN. Completely fill in the circles.

Get immediate Directed Reading quiz results and CE credit when you take your test online at www.asrt.org/drquiz.

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

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10 OOOOO 20 OOOOO

No Photocopies Accepted
Shared Experience

Additional Guidelines

The “Stopping the Chain of Infection in the Radiology Suite” Directed Reading by Jennifer Schmidt (September/October 2012) is a great article. I believe all R.T.s and students should be required to read it.

I do have one suggestion for the author. In the section where the author discusses the hepatitis B vaccine, I am disappointed she did not address the CDC’s recommendation for all health care employees with direct patient contact to follow the 3-treatment vaccine series with a hepatitis B antibody (anti-HBs) test to prove that the vaccine treatment took effect. A number of people who complete the HBV vaccination series do not end up protected. Not knowing the positive or negative findings of the series means that when potential transmission occurs from an infected patient, the R.T. will have to go through the entire treatment series. Having a known positive anti-HBs test result means protection is in place for the worker and no treatment is required in the event of a contaminated stick from an HBV patient. CDC guidelines include the anti-HBs test as a follow-up, but very few people follow this important guideline. I hope this feedback is helpful.

Denise Moore, MS, R.T.(R)
Professor Emeritus, Radiologic Technology
Sinclair Community College
Dayton, Ohio

The Author Responds:

Denise, I am happy to hear you enjoyed the article. I appreciate your feedback. I will try to be more detailed regarding such important recommendations in the future.

Jennifer M Schmidt, MS, R.T.(R)(M)
Field Epidemiologist
North Dakota Department of Health
Jamestown, North Dakota

Management Strategies

As I was reading the Directed Reading “Managerial Strategies for Creating an Effective Work Environment” by Kimberly Luse (March/April 2013), I almost felt as if the author had been part of my department or that I had a part in writing the article. The article was well thought out and accurately described many of the situations and behaviors that occur in an imaging department. I was able to take the information in this reading and match it to issues/concerns that have been addressed or are being addressed in my department.

My department went through reorganization 4 years ago, and we are finally beginning to reap the benefits of creating a total team environment. Because the imaging department is made up of technologists across varying modalities, we are in different stages of the team development life cycle: forming, storming, norming, and performing. I have been documenting the entire
reorganization project to use as a reference to promote what we have done well and communicate our next steps. Thank you to the ASRT for providing this article. I really enjoyed the read.

Jerri Doyle, MAOM, R.T.(R)(CT)
Imaging Manager, ASRT Delegate, and Montana Society of Radiologic Technologists President-Elect
Butte, Montana

Stress Management

Regarding the Directed Reading “Stress Management for the Radiologic Technologist” (September/October 2012), I noticed the introduction example of no employee answering a telephone. During my student days more than 30 years ago, lower management professed (confessed?) to operating with a skeleton crew. In fact, now most skeleton crews have bones missing. This Directed Reading fails to acknowledge this prime cause of stress and instead considers the problem to be the technologist. In any business, a well-staffed department does not create profession-induced stress, nor should such encourage unnecessary procedures.

Administrators reel at the thought of overstaffing. Perhaps the issue is that health care has become a business constantly cutting costs and increasing profits. That is the shame of society. Having a fire station does not mean to start fires, but the public deplores service cuts in that area.

As a side note, in the same issue, there is an article discussing excessive radiation levels in patient exposures. During clinic visits while researching equipment prior to purchasing our wireless DR U-arm machine, I found locations that were radiating patients 5 times higher than my old machine. It is too bad no agent exists to inspect for these occurrences.

Carl Brooks, BA, R.T.(R)
Belleville, Illinois

The Author Responds:

It seems we are similar in experience — my student days were 26 years ago! In fact, the example mentioned is based on my own experiences being the only technologist scheduled on a shift (with no students). I truly agree with the point that understaffing is a major cause of stress and stress-related mistakes. The point of my article, however, was to attempt to arm technologists and others in high-stress fields with tools to cope with an environment that is all too often not under one’s control. The article also dealt with stress caused by change, but the real challenge is to develop the ability to adapt to a situation that is unlikely to change in the near future, such as budget cuts and understaffing.

I most definitely feel it is upon the technologists to develop their own stress management strategies, as a measure of “self-defense.” Who better to look out for your interests? I maintain that you can’t change what happens to you in life, only the way in which you react.

Jeannine M Romano, BA, R.T.(R)(CV)(MR)
Supervisor of Radiology and Cardiodiagnostic Services
Louis A Johnson VA Medical Center
Clarksburg, West Virginia
WebQuests Can Supplement Student Learning of Radiographic Anatomy

John L. Callaway, MEd, R.T.(R)
Lisa A Rhoden, MEd, R.T.(R), CNMT

First-year students come into a radiography program with a basic understanding of human anatomy, but they are required to take a course on radiographic anatomy, which goes much more in-depth about the bones of the human body. The course reviews and identifies every bone, the parts of each bone, and its position in the body. For the students to perform adequate radiographs, they must be able to visualize every bone. This material is difficult to learn, considering how many bones students must be able to identify. To facilitate learning and provide variety, instructors may consider using a WebQuest.

Because all students do not learn in the same way, it is important to provide them with different methods of learning. Some students learn from seeing, some learn by listening, while others need more hands-on experience. Using a narrated PowerPoint presentation along with a WebQuest, the instructor can employ a hybrid instructional method that is both face-to-face and online. This hybrid method requires the instructor to play 2 roles: teacher and facilitator. In the classroom, the teacher presents the material to the students. As a facilitator, the instructor provides Web links that students can use on their own to strengthen their knowledge of the material covered in the classroom.

WebQuest 101

A WebQuest is a general term that describes curriculum projects in which students explore websites to find and analyze information about a topic. Bernie Dodge created this way of teaching and named it WebQuest in 1995 while he was a professor of educational technology at San Diego State University. The concept he developed allows students to engage actively with online resources. Dodge’s goal was to teach his students to use online resources, integrate the information they found, and decide whether and how the information could be used.2

Using a WebQuest, radiography students can view Web pages that offer various methods of instruction. They are able to supplement what they learn in the classroom setting and gain a better understanding of human anatomy in a way that is fun and creative. According to an article by Gaskill et al, WebQuests are constructivist activities in which students use Web resources to learn about school topics, and they are generally well received by students.3

The constructivist approach to learning is based on the experiences of learners and how they build their understanding of the world. Constructivists believe learners must use their experiences to gain reliable, trustworthy knowledge. Active participation in learning will build a more solid foundation of understanding than simply being told how to do something. Drawing on the experience students acquire by exploring specific websites allows them to gain a better understanding of the material than they would by listening to a teacher lecture. By giving direction and not simply reciting the information, instructors can use WebQuests to allow students to discover information on their own.

WebQuests also provide educators with an instructional framework to create meaningful online learning activities. By allowing students to control how they learn, teachers also can provide a model for future courses and topics. This model allows for continual improvement of coursework to enhance the learner’s experience and self-efficacy.
Dodge focused on 6 components that should be included in a WebQuest:

- **Introduction** – the goal is to make the activity desirable and fun for students. When students are excited about a subject, they will be more motivated to learn.
- **Task** – describes what the students will produce in the WebQuest. Creating the task is the most difficult part of developing a WebQuest because so many things can be accomplished. The first goal of the WebQuest creator is to decide what the students need to learn.
- **Process** – refers to the actual steps the students should follow to accomplish the task. To aid the students in their understanding, it is helpful to include demonstrations along with the written process.
- **Resources** – consists of a list of other material that might be helpful for the students or resources that were used in the creation of the WebQuest. Providing this information helps focus the exercise on processing information rather than just locating it. In this section, instructors may include offline resources for students to explore on their own, such as visiting lecturers, printed material, and audiovisuals, which can greatly contribute to students’ interest.
- **Evaluation** – discusses exactly how the students will be graded and what is expected of them. The expectations must be fair, relevant to the topic, clear, and consistent. If the students cannot figure out what is expected, they will have difficulty succeeding.
- **Conclusion** – reviews the purpose of the WebQuest, along with a way to contact the instructor with questions or comments.

One important aspect of WebQuests is that they can be used across many disciplines. Dodge created the first WebQuest as an educational simulation for use with student teachers, but they can be used in any discipline that requires students to use higher-level thinking. WebQuests put more responsibility on the learners and lend themselves particularly well to topics and tasks with many possible results.

**Online Opportunity**

When using a WebQuest, teachers can preselect sites for students, which enables students to focus on using the information rather than spending time looking for it on multiple sites. Instructors can include sites that are informative but also promote active participation from the students. Because WebQuest activities are inquiry-based, the students must actively participate in learning instead of passively soaking up information. The websites must be helpful but also motivate and engage students.

All of the resources included in the WebQuest are presented in a step-by-step format so instructors can keep students focused on relevant information and tasks. WebQuests naturally create opportunities for students to interact with the course material, their instructors, and each other in a way that traditional lectures might not provide. According to an article by Susan Jones:

> Using WebQuest as a form of multimedia in the classroom allows students to have fun, learn more, develop abilities to collaborate, to recognize and analyze problems, learn how to search for, acquire and use large amounts of information, and to apply technology to solve real-world problems.

**Creating a WebQuest**

The work required from the instructor when developing WebQuests is rather minimal. They can be created easily using existing templates found on the Internet and personalized to fit an instructor’s need. Free websites provide WebQuest templates while also offering numerous examples that can be used as a guide (see **Box 1**). All of the templates closely follow the outline Dodge created, but because this concept has become more common, teachers can view numerous examples created by others. Following these templates and examples is easy, even for the computer novice. As long as the instructor can create a document with hyperlinks, he or she can create a WebQuest. This means a WebQuest can be created in Word, PowerPoint, and even Excel with a few additional steps. The most difficult aspect is deciding what tasks to include to keep students focused on the topic.

Once the WebQuest is created, it can be used multiple times and modified if necessary. Most of the templates allow the instructor to simply fill in blanks with the sites he or she wants to include, as well as tasks that lead to a final goal. Templates come in different themes,
In conjunction with classroom presentations, WebQuests can be an important component to increasing a student’s understanding of new material. They also can be a tool for instructors to offer different methods of teaching, supplement learning, and potentially reach more students. A good WebQuest will engage students in their own learning process.

### Active Participation

A WebQuest offers students a learning tool that requires active participation. Online quizzes can test a student’s knowledge of anatomy, interactive sites can display 3-D images, and labeled drawings can help students visualize each part of a bone. This type of website makes learning fun for students while giving them a better understanding of anatomy. Using dry bone specimens and phantoms is an important component of learning anatomy, but allowing students the opportunity to use technology engages them in the process, and ultimately, they gain a better understanding of the material. Likewise, PowerPoint presentations that highlight and label the bones offer a good way to introduce anatomy, but simply showing students a presentation is not going to create a solid understanding of the information. Allowing students to strengthen their knowledge through interactive websites selected by the instructor is an excellent way to involve them in learning and increase comprehension (see Box 2).

Opportunities for students to ask the instructor questions about anatomy and work in small groups to review radiographic images and discuss each bone may be provided in the classroom. Giving students access to a WebQuest at the beginning of the course provides ample opportunity for them to use the online resources for individual practice, too, and they can access the information at any time. Students can take the knowledge they gain in the classroom and use it when they visit each website in the WebQuest. The instructor may use information from these websites when creating quizzes to ensure students are using the WebQuest resources and to provide a formative assessment of the students as the course progresses. Using these websites for practice and as study guides allows the students to better understand this difficult subject.

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<td>Skull Bones &amp; Structures Slideshow #1 – <a href="http://www.gwc.maricopa.edu/class/bio201/skull/SkullSlideshow1/index_PP1.htm">www.gwc.maricopa.edu/class/bio201/skull/SkullSlideshow1/index_PP1.htm</a></td>
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In conjunction with classroom presentations, WebQuests can be an important component to increasing a student’s understanding of new material. They also can be a tool for instructors to offer different methods of teaching, supplement learning, and potentially reach more students. A good WebQuest will engage students in their own learning process.

John L. Callaway, MEd, R.T.(R), is the clinical coordinator and an instructor at the University of Arkansas for Medical Sciences (UAMS) College of Health Professions, Department of Imaging and Radiation Sciences, Division of Radiologic Imaging Sciences, in Little Rock, Arkansas. Callaway graduated from UAMS in 1995 with a bachelor of science degree in radiologic technology, and he earned his master of education degree from the University of Arkansas at Little Rock in 2012. He has taught radiographic positioning courses and labs, as well as radiographic anatomy. Callaway received the Faculty Gold Key Award and Outstanding Student Award while studying at UAMS. He is an active member of the Association of Educators in Imaging and Radiologic Sciences and is currently in charge of the clinical portion of the Radiologic Imaging Sciences program.
Lisa A Rhoden, MEd, R.T.(R), CNMT, is the assistant program director and an instructor at UAMS College of Health Professions in Little Rock, Arkansas. Rhoden graduated from UAMS with an associate of science degree in radiologic technology (2003) and a bachelor of science degree in nuclear medicine technology (2004). She completed her master of education degree from the University of Arkansas at Little Rock in 2012. Rhoden has taught radiographic anatomy, basic and advanced patient care, radiation protection, and several other courses in the program. She received the Faculty Gold Key Award and is a member of the Association of Educators in Imaging and Radiologic Sciences. Rhoden is pursuing a PhD in health prevention and promotion research at UAMS.

References
Radiology outreach brings sustainable medical imaging services to resource-poor communities. The World Health Organization (WHO) estimates that approximately two-thirds of the world population — 4 billion people — lack access to adequate, appropriate, reliable, and safe diagnostic and interventional radiology services. Increased awareness of this “imaging gap” between the developed and developing world has encouraged radiology professionals to take action through outreach initiatives. However, poor preparation and planning often result in wasted resources and feelings of disappointment. Thus, drafting a well-researched country report can be an important first step for any group interested in developing a meaningful and sustainable outreach project.

A country report is a multifaceted review of a partnered facility’s country that is designed to support sustainable project development and encourage long-term collaboration. A “partnered facility” is a health care facility in the developing world that has aligned with a radiology outreach project team to improve the facility’s radiology services. To avoid a paternalistic approach, include the facility and its project-related personnel as full partners in the project. Their help, input, and point of view are critical to project success. Even for small local programs, understanding the country as a whole and how nationwide issues affect the local partner can be important. Although there is no set format for a country report, this article presents the approach used by RAD-AID International, a nonprofit organization that specializes in organizing and leading successful radiology outreach initiatives (see Figure).

The information contained in a radiology-specific country report can serve multiple purposes:

- A screening tool – allows project team members to assess whether the request for support within a potential partnered country fits the established mission of the outreach group. For example, a project group focused on women’s health issues might want to understand the epidemiology, screening, and treatment of breast cancer at a national level before committing to a specific local breast imaging–related project.
- A method to identify possible hurdles – helps a group to detect political, cultural, resource, and regulatory issues present at a national level that may affect the project.
Writing a Country Report for Use in Radiology Outreach Initiatives

- Insight for volunteers – offers potentially important information about a country’s history, culture, politics, and customs. For example, in some regions tucking an exchanged business card in a shirt pocket or writing on the back of a business card could result in a poor first impression.
- An expression of commitment – an informative, detailed country report demonstrates seriousness and due diligence that can build confidence and rapport with partners and funders.

Components of a Country Report

A comprehensive country report is most effective when broken into 3 major sections: a general country profile, a focused review of national health care, and a detailed report on the country’s available radiology resources and services. Each section has recommended subsections to help ensure the necessary details are captured (see Table).

General Country Profile

The general country profile provides the project team members with background knowledge of the country under consideration. Draft this section assuming the reader has no exposure to the country. RAD-AID breaks the country profile into 5 subsections:

- Geography and population.
- History and culture.
- Government and legal system.
- Economy and employment.
- Physical and technological infrastructure.

Table

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</table>

Geography and Population

The geography and population section should include an image of the country’s national flag and a map of the country that identifies its major cities and neighboring nations. You also should include a brief description of the climate, seasonal cycles, notable geographic landmarks (eg, mountain ranges and bodies of water), and geographic area (sq km). In addition, include a table containing population data, such as total population and world rank, annual population growth rate and world rank, percent of total population in rural areas, and stratified population age distribution. You also may include the United Nations human development index score, which is a useful composite statistic of life expectancy, education, and income indices used to rank countries.

History and Culture

The second section of the general country profile should briefly summarize the history and cultural and religious practices of the ethnic groups residing within the country. This could include information about colonial and postcolonial history, involvement in armed conflicts, or natural disasters that changed the country. It might be helpful to provide the historical data in a timeline format to depict the chronological order of the events. In addition, when discussing cultural and religious practices, you should address customs influencing business etiquette and health delivery. Provide details related to the primary languages and dialects spoken, as well as the level of comprehension and use of the English language within the country.

Government and Legal System

Include a description of the current system of government (eg, democracy, monarchy, or military rule), including brief descriptions of the executive, judicial, and legislative branches. The World Bank publishes 6 worldwide governance indicators for 215 economies:

- Individual voice and accountability.
- Political stability and absence of violence.
- Government effectiveness.
- Regulatory quality.
- Rule of law.
- Control of corruption.

These indicators are available free on the Internet and can be compared within the country report to individual and aggregate indicators of peer nations, world regions, and different levels of economic development. Depending on the types of projects a group plans to undertake, including information about the country’s tort and litigation system also could be useful. If the project group plans to provide direct medical care to patients in another country, then this topic can be crucial. For radiology, this issue can arise when planning an outreach project involving teleradiology services.

Economy and Employment

The subsection about the economy and employment includes details about the major industries within the country, sources and amounts of international aid, as well as statistics, including gross national income and world rank, gross national income per capita and world rank, unemployment rate, and annual inflation rate. The gross national income is the sum of the incomes of residents of an economy in a given period, and this number per capita can be used to classify the country as low income, lower middle income, upper middle income, and high income based on World Bank criteria. The first 3 categories include the nations of the developing world. The high-income countries comprise the developed world.

Also consider including the World Bank “ease of doing business” index. This metric is a composite of ranks, including ease of starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency. You may want to separately report all or specific individual ranks in the country report, depending on the goals and objectives of your project.

Physical and Technological Infrastructure

The final section of the general country profile deals with the country’s physical infrastructure, including communications technology, electricity, and transportation. Include information about the use of and access to communication methods (eg, cellular, Web-based, and postal mail) within the country to help identify the best methods for maintaining communication with local project partners. You also should include information related to the availability and consumption of power sources, particularly the frequency of load-shedding (also known as rolling blackouts), power-sharing strategies, and the effect on power reliability.
Finally, report transportation statistics such as total road density, percent of paved roads, and the number of passenger cars in use. This infrastructure-related data can prove critical in predicting challenges volunteers might encounter.

**National Health Care Sector Review**

Next, the report narrows its focus to an examination of the health care sector. The national health care review is divided into 2 distinct sections: the national health profile and a description of the national health care structure.

**National Health Care Profile**

The national health profile reports the greatest threats to public health, such as mortality and prevalent infectious diseases, cancers, and other acute and chronic illnesses. The national health profile involves collecting and sharing data that indicate the overall health of a country (eg, rates of mortality for the overall population, infants, and mothers). Because mortality rates alone do not give a complete picture, provide age-standardized disability-adjusted life year rates to serve as a summary measure indicating the burden of disease. This way, the causes of death that have little related disability (eg, drowning or measles) can be compared to diseases that do not cause death but do cause disability (eg, cataract causing blindness).

In addition, note data related to the rates of diseases and conditions causing the greatest mortality and morbidity. This includes rates of infectious and parasitic diseases, maternal and perinatal issues, nutritional deficiencies, malignant neoplasms, cardiovascular conditions, and trauma. Include statistics regarding health trends such as increases or decreases in the health and disease conditions of greatest concern over the past few decades. Try to explain any recognized trends in the data, such as implementation or discontinuation of public health campaigns or disease-screening programs. National health statistics serve as benchmarks for the overall effectiveness of the current health care system.

**National Health Care Structure**

The second part of this section examines:

- Health system structure and policy.
- Health service coverage across the population.
- Health care expenditure.
- Health workforce and infrastructure.

Health system structure and policy discussion includes details about the number of health care facilities within the country, their general distribution, and classifications of the health care facility types, such as academic centers, large urban medical centers, midsized regional tertiary care clinics, or small rural or remote clinics. A brief explanation of the patient referral process among the facility types could prove useful for project planning and might best be presented as a hierarchical diagram of the levels of care. In addition, the report should contain data regarding percentage of care as provided by various health care provider types (ie, government, privately owned, and nonprofit organizations). You also might include general information regarding the level of quality and affordability of care, as well as payment schemes provided or accepted by each health care provider type. Be sure to note information about government programs implemented to increase availability, affordability, efficiency, or overall access to care.

Because medical imaging is not likely useful if the diagnosed pathologies cannot be treated, include information about health service coverage while keeping the outreach project goals in mind. For instance, before implementing a chest screening program for tuberculosis, it would be prudent to first analyze and evaluate the nationwide rates of smear-positive tuberculosis case detection and treatment to ensure that implementing a screening program is the best use of resources. The WHO collects and shares this data online for use by researchers.

When discussing the country’s health care expenditures, note per capita costs, expenditure as a percentage of the gross domestic product, and out-of-pocket expenses on privately provided care. Also share available information about how the public component of the health care system is financed. Such information is important when recommending business models that will allow a partner imaging facility to maintain financial solvency and provide sustainable imaging services.

Finally, a description of the general health care workforce should be provided. The WHO provides data on the number of hospital beds, nurses and midwives, physicians, and pharmaceutical personnel for most countries. A discussion about similar numbers for radiology-specific staff should follow in the last section of the country report.
National Radiology Profile

The final section of the country report — and of greatest interest to a radiology outreach project team — analyzes available medical imaging services within the partnered country. It is here that a focused view of the current state of the national radiology infrastructure can be assessed, leading to the initial steps in project approval and planning. The national radiology profile can be broken into 4 categories of focus:

- Radiology workforce.
- Training and professional representation.
- Equipment inventory and distribution.
- Regulation and policy.

Radiology Workforce

A comprehensive review of the radiology workforce involves sharing details about the number and relative distribution of individuals functioning within the roles of radiologists and technologists, radiation oncologists, radiation therapists, radiology-specific nursing staff, physicists, radiation safety officers, radiology educators, and imaging device engineers. The primary question that should guide the data collection process is whether there are enough medical imaging specialists to meet the needs of the partnered country appropriately.

Training and Professional Representation

In regards to the level of training of those practicing as medical imaging professionals, document information about the academic programs available, including number, geographic location, and general program requirements. Sources of radiology-specific education could range from doctoral degree programs to an annual educational seminar, with both sides of the spectrum warranting mention within the report. Note information related to any radiology-related professional societies, if present, including membership size, details about recurring annual scientific or administrative meetings, and primary organizational contacts.

Equipment Inventory and Distribution

Use a table to illustrate an inventory of available imaging equipment and its distribution within the country, followed by subsections dedicated to specific imaging modalities available within the country. Each modality-specific subsection should highlight the current level of equipment technology in use (eg, single-slice vs multislice computed tomography; film-screen vs digital radiography systems). Include information about the most common type and frequency of exams performed within each modality, if available. It also is important to include a subsection dedicated to image archiving, highlighting the extent to which picture archiving communication systems and teleradiology services are used. When possible, mention differentiation between imaging technology available within the private sector compared with the public sector. Furthermore, note details about local manufacturers of radiology-related devices or supplies (eg, contrast media and catheters), if present.

Radiology Regulation and Policy

Finally, make an effort to outline radiology-related regulation and policies in place. You should identify the presence of a national authority responsible for implementing and enforcing regulation of medical devices. If a government body is present, does it specifically regulate medical imaging equipment? Furthermore, is there a national medical device or health technology policy, and if so, how does it affect radiology services across the country? Perhaps all medical device procurement is carried out at the national level. Do national guidelines or recommendations address the procurement or receipt of medical device donations? If so, where can they be found? Use a similar line of questioning when searching for other potential documents of importance related to the oversight and regulation (or lack thereof) of radiation protection for patients and personnel, licensure and certification of medical imaging professionals, and other related materials. A working knowledge of such regulations as they pertain to medical imaging will prevent wasting the outreach project team’s time, money, and energy.

Concluding the Report

Conclude the country report with a brief synopsis of current government-funded or international humanitarian involvement focused on building the country’s radiology infrastructure. Doing so provides the outreach team an opportunity to establish relationships with other organizations interested in partnering on common goals.
Data Collection

The process of data collection is perhaps the most challenging aspect of drafting a country report. Writing a country report requires a comprehensive literature review that uses investigational strategies to uncover useful documents and reports that might not be readily available on the Internet. Although the process requires searching Web-based databases, it also requires searching peer-reviewed publications and government reports, as well as contacting country-specific governmental and nonprofit organizations. Adhering to an evidence-based approach is critical to ensure the information within the final country report is reliable. Keep in mind that information garnered from any source might be fragmented, contradictory, unreliable, ambiguous, deceptive, or wrong. Cross-reference the data when you have any doubts about its accuracy.

Online Resources

You can gain many leads by searching the Internet for relevant articles, books, news reports, and videos. Most people who work in radiology are familiar with the U.S. National Library of Medicine PubMed database of biomedical scholarly articles and online books (www.pubmed.gov). PubMed can be searched using a combination of Boolean operators (and, or, not) and Medical Subject Headings (MeSH). MeSH terms are part of a controlled, hierarchical vocabulary the National Library of Medicine uses to index and catalog the 22 million citations and abstracts in the PubMed database. Simply using the MeSH heading “radiology” along with the country of interest can identify some intriguing articles, though not always related to medical imaging specifically within underserved communities.

Another PubMed search strategy is to run a search with the MeSH heading “radiology outreach.” Conducting this search strategy in August 2013 resulted in 161 articles. Alternatively, RAD-AID uses a customized search strategy combining keywords and MeSH terms to maintain its own bibliography of more than 1000 peer-reviewed publications of relevance to imaging in developing countries (http://goo.gl/Gb7WAq).²

JSTOR (www.jstor.org) is another useful online resource, with a digital database of more than 1500 searchable academic journals, books, and primary sources. In addition to including medicine and allied health titles, JSTOR catalogs titles in the arts, business, economics, history, humanities, law, science, mathematics, and social sciences. Searching JSTOR can yield useful results for the sections of the country report beyond the biomedical focus of PubMed.

Web search engines such as Google (www.google.com) are also important sources of general information, news, and videos. However, be sure to confirm findings for accuracy and vet sources for reliability. Web searches can be customized and saved with periodic e-mail or RSS feed updates generated as new results are found. Similar features are available for PubMed and JSTOR.

Organizational Reports and Databases

Despite the surprisingly large number of available articles related to imaging in developing countries, additional sources will almost certainly be required to provide the country-specific data required to draft a comprehensive country report. For this reason, you must become familiar with the reports and Web-based data sets published by national and international organizations that measure and analyze economic, educational, and health-related indicators of human development. Although most people are familiar with the role and function of centralized national government organizations, many have less exposure to intergovernmental organizations and their international membership, scope, and presence. Intergovernmental organizations are an important aspect of public international law, and they also are a great resource for collecting and analyzing data for use in making informed international policy decisions. More importantly, an intergovernmental organization is accountable to the governments it serves and often holds the data it collects and distributes to a higher level of integrity.

Reliable data is needed to set baselines, develop goals and targets, monitor progress, and evaluate the effect of established service programs. For this reason, several intergovernmental organizations have taken proactive efforts to increase public access to datasets related to indicators of human development. Broader access to such data allows policymakers and advocacy groups to make better-informed decisions, accurately measure improvements, and subsequently offer valuable tools for supporting research by journalists, members
of academia, and others, which helps to broaden the understanding of global issues. Working closely with representatives stationed in respective regions, intergovernmental organizations are guided by professional standards in the collection, compilation, and dissemination of data to ensure all data users can have confidence in the data produced. However, much of the data comes from the statistical systems of member countries, and the quality of global data depends heavily on how well these national systems perform. Often, intergovernmental organizations work to help developing countries improve the capacity, efficiency, and effectiveness of their national statistical systems.

Organizations to Know

Central Intelligence Agency

The Central Intelligence Agency maintains The World Factbook, a tremendous resource for compiling the general country profile section of the country report. The Factbook was created as an annual summary and update to the encyclopedic National Intelligence Survey studies and is now available online (https://www.cia.gov/library/publications/the-world-factbook/). The Factbook provides information about the history, people, government, economy, geography, communications, transportation, military, and transnational issues for 267 world entities. The site includes flags of the world as well as maps of the major world regions, world oceans, and standard time zones.

The World Bank

The World Bank (www.worldbank.org), which serves as a source of financial and technical assistance to developing countries around the world, is perhaps the best resource for drafting the economic subsection of the general country profile. Although not a bank in the ordinary sense, the World Bank offers a unique partnership to reduce poverty and support development. It is composed of 2 institutions managed by 188 member countries, namely the International Bank for Reconstruction and Development and the International Development Association. The International Bank for Reconstruction and Development aims to reduce poverty in middle-income and creditworthy poorer countries, while the International Development Association focuses on the world’s poorest countries. At the World Bank, the Development Data Group coordinates statistical work and maintains macro, financial, and sector databases.

International Telecommunication Union and International Energy Agency

Two organizations are especially helpful resources for data about national infrastructure. The International Telecommunication Union (www.itu.int) publishes an index based on internationally agreed upon indicators to compare information and communication technologies’ performance within and across countries.

The International Energy Agency (www.iea.org) is an autonomous organization that works to ensure reliable, affordable, and clean energy. One of the International Energy Agency’s main areas of focus is energy security, and data regarding energy infrastructure can be found within its published reports and database.

World Health Organization

Another important intergovernmental organization is the WHO (www.who.int), which is the directing and coordinating authority for health within the United Nations system. The WHO is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, articulating evidence-based policy options, providing technical support to countries, and monitoring and assessing health trends.

First published in 1995, the WHO’s World Health Report combines an assessment of global health, including statistics relating to all countries, with a focus on a specific trending health care subject. The report provides countries, donor agencies, international organizations, and others with information to help them make policy and funding decisions.

In addition to the annual World Health Report, the WHO publishes World Health Statistics, which compiles annual health-related data for its 194 member states and summarizes the progress made toward achieving the health-related targets established by the United Nations. A recent addition to this report highlights the topic of reducing the gaps between the world’s most advantaged and least advantaged countries and current trends in official development assistance for health.

The reports are available at no cost on the WHO website. The WHO databank provides other potentially useful data such as antiretroviral coverage among...
HIV-infected people, percentage of births attended by skilled personnel, and rate of antenatal health care.

United Nations Children’s Fund

The United Nations Children’s Fund (UNICEF) provides long-term community-level humanitarian and developmental assistance to children and mothers in developing regions (www.unicef.org). Most of UNICEF’s work is in the field, with staff in more than 190 countries and territories carrying out the organization’s mission through programs developed with host governments. UNICEF annually publishes economic and social statistics about the countries and territories of the world — with particular reference to children’s well-being — in the State of the World’s Children report, which includes tables combining statistics for all countries. Furthermore, UNICEF helps countries collect data through Multiple Indicator Cluster Surveys, an international household survey program. Since the mid-1990s, the surveys have enabled many countries to produce statistically sound and internationally comparable estimates for a range of health-related indicators.

Professional Societies and Local Contacts

For the highly specific data items, particularly those needed for analyzing available medical imaging services, it may be helpful to contact local health departments, ministries of health, other ministries (eg, finance, culture, and transportation), and national professional societies with a radiology focus. You can locate many departments and ministries with a brief Internet search; an extensive list also can be found on the WHO European Region website. Many department and ministry websites have useful country-specific health reports and open-access databases available for review. However, a brief e-mail or phone call to explain the intended use of the collected information might help uncover radiology-specific data that could otherwise be difficult to locate.

The same is true of professional societies. For example, the International Society of Radiology (www.isradiology.org) and the International Society of Radiographers & Radiological Technologists (www.isrrt.org) have comprehensive listings of member organizations from countries around the world, along with their respective websites and contact information. Not only is reaching out for local support a great strategy for discovering data-rich documents, but it also could prove useful later in the outreach project when local support is needed to deliver enhanced imaging services.

The information found on international websites often is not in English. However, free Internet translator resources are available (http://translate.google.com or www.babelfish.com). The Chrome Web browser (Google Inc, Mountain View, California) has a built-in feature that automatically offers to translate Web pages that are not in English.

Conducting an On-site Assessment

Even after conducting the research required to write a country report, to understand fully the needs, strengths, and limitations of a partnered facility, you must perform an on-site assessment. RAD-AID developed an analytical framework called Radiology-Readiness that you can use to collect data for such an assessment. The Radiology-Readiness assessment picks up where the country report leaves off by helping you collect data relevant to a specific facility or group of facilities, including physical infrastructure, technical infrastructure, human resources, clinical resources, financial resources, radiology infrastructure, local political and cultural issues, and local disease epidemiology. The country report can help focus your assessment by identifying key topics that must be addressed at the local level. For example, if the country report states that there is no national regulatory body for radiation safety, the on-site assessor might want to spend extra time learning about the methods used at the partnered facility to protect workers and patients from radiation exposure.

The details of performing an assessment are beyond the scope of this article. However, a detailed explanation of the Radiology-Readiness approach has been published elsewhere and can also be found at www.rad-aid.org.

When completed, you can merge the country report and Radiology-Readiness assessment and submit the combined document for peer-reviewed publication. (Be aware that decision makers at the assessed facility must grant permission to release the information before components of the Radiology-Readiness assessment can be published.) Including decision makers and others from the partnered facility as co-authors can further build the relationship from which future collaborative projects may develop. In addition, a published country report and Radiology-Readiness assessment can be used by others.
interested in developing outreach projects in similar parts of the world.

**Summary**

Writing a country report for use in radiology outreach initiatives is a critical first step for any project team dedicated to providing sustainable support of human and financial resources. Preparation is the key to outreach project success, and a well-drafted report, especially if published, can serve the needs of various individuals and groups through the completion of the project.

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**References**


See the RAD-AID country report for Ethiopia in the online version of this article.

For information regarding outreach initiatives in the radiologic sciences, visit www.asrt.foundation.org > Get Involved > Community Outreach.
In the Clinic

Investigating Orthogonal Radiography in the Diagnosis of Radial Head Fractures

Christopher Ira Wertz, MSRS, R.T.(R)  Devin Schneyder, R.T.(R)
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Fractures of the radial head constitute approximately one-third of all elbow fractures. The mechanism of injury frequently involves a fall on an outstretched hand or direct trauma to the joint. Most patients will resist movement of the injured arm, which presents a hardship to the radiographer and patient especially because the ulna can obscure the radial head, traditionally visualized with an external oblique position that is challenging for patients with these types of injuries. The literature discusses alternative methods for these patients, including the Coyle method that uses a 45° cephalic tube tilt to separate the ulna from the radius. If the elbow is in flexion, this method offers a distinct, though distorted, view of the joint and can be used with patients who cannot extend their arm. Variations of the Coyle method can be performed in recumbent and sitting positions. Although the images are distorted because the image receptor does not intercept the central ray (CR) at a right angle, the Coyle method and its variations provide alternative views of the radial head without the superimposition of the ulna.

In contrast, when the trauma patient presents with the arm extended, the external oblique is difficult to obtain. Pain, effusion in the elbow, and tenderness over the radial head are typical of radial head injuries. Some patients cannot tolerate the leaning required to put the interepicondylar plane in a 45° oblique position for the external oblique. Severely injured patients cannot be moved into this position; elderly patients also often have difficulty assuming the position. If the patient’s elbow is extended, the Coyle method offers no advantage. If the patient is recumbent with the arm extended, the entire body sometimes can be rotated into a posterior oblique position, and the arm naturally rotates externally. Recumbent positions make it easier to obtain the external oblique position with a vertical beam. However, when the patient is sitting, the throbbing typically associated with the injury makes it difficult to lean laterally and is awkward and painful for the patient. Regardless, many patients present in the sitting or upright position, and when this happens, an orthogonal approach should be considered.

The term *orthogonal* means right angle. “Two views 90° from each other” is a mantra of educators to students; it should always be done. Orthogonal comes from the Greek *ortho* meaning right and *gon* meaning angled. Thus, the investigation performed for this article shadows the Greek definition of using right angles, but for a single oblique position rather than a 2-view minimum approach. For this study, the orthogonal method employed a 45° CR angle and a 45° tilt of the image receptor, resulting in right angle radiography of the elbow. The traditional anteroposterior and lateral projections still would be performed, but the right angle for the oblique position would be obtained by a CR/image receptor tilt. With this method, the elbow joint remains in the supinated position, and the resultant image is analogous to the traditional approach. It could be compared to C-arm methodology (ie, the body part remains in the same orientation, and the technologist captures a unique view by stopping the rotation of the C-arm as it rotates around the body part). However, the technologist...
would use a stationary tube and make the exposure at the stop.

The hypothesis alleged that by applying an orthogonal methodology to the elbow joint, a position not discussed in traditional textbooks could be obtained with any standard x-ray tube. Likewise, the advent of wireless detectors and mobile lateral cassette holders would make the external oblique position easier to acquire without rotating the patient’s arm. An additional postulation was that the position also could be performed by using a 45° rotating upright Bucky with a perpendicular CR angle. The assumption is that if the CR/image receptor is placed at a 45° angle, the resulting image will be identical to radiographs obtained with the traditional external oblique position.

**Laboratory Testing**

The 45° CR/image receptor orthogonal method originated in a laboratory setting at Idaho State University. An elbow phantom was placed on sponges to simulate the position. Caution was used to ensure the interepicondylar plane was parallel to the tabletop. A 45° sponge supported the image receptor, and the tube was tilted 45° so the CR was perpendicular to the image receptor (see Figure 1).

The setup for the traditional method included rotating the phantom so the interepicondylar plane was at a 45° angle to the image receptor. This position provided an external oblique without need to angle the tube. The resultant image was used as a control image to compare to the orthogonal method.

The CR must enter the medial side of the arm for separation of the radial head to occur. If in doubt, one can deduce that the traditional external oblique raises the medial side of the arm when the patient leans laterally. Therefore, the CR enters medially and exits the downside or lateral side of the arm when performed by way of a vertical beam (see Figure 2). This same logic holds true with the angled approach. Although the arm remains supinated, the CR enters the medial side and exits the lateral side of the joint.

Students from 4 different lab sections at Idaho State University performed both the orthogonal and routine methods to test the hypothesis that the radiographs would look the same. Each lab section produced a series of radiographs and compared the images.

Although some images were not identical, investigation revealed that either the phantom was not correctly oriented or the CR angle of the tube or image receptor was incorrect. When either problem occurred, the images were repeated immediately by the same individuals. After repeating with proper orientation or angling, each lab section demonstrated almost identical images. The results for all labs found no major differences in the outcome when comparing both methods (see Figure 3).
Investigating Orthogonal Radiography in the Diagnosis of Radial Head Fractures

extending his arm fully; however, obtaining radiographs using the orthogonal approach was simple. All images were of sufficient quality and nearly identical to radiographs typically taken with the traditional approach. The technologists remarked that this procedure was easier than they first envisioned. Most patients were easily moved into this new position.

Radiologists were blinded to the change of procedure (ie, they were unaware the study was taking place). It is interesting to note that the radiologists did not comment on positioning in any exam report and that no objections were noted in the radiologists’ interpretation. Most radiographs demonstrated good separation of the radial head from the ulna. Comparatively, the radiographs had extending his arm fully; however, obtaining radiographs using the orthogonal approach was simple. All images were of sufficient quality and nearly identical to radiographs typically taken with the traditional approach. The technologists remarked that this procedure was easier than they first envisioned. Most patients were easily moved into this new position.

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the same appearance as the external oblique performed with the traditional rotational method.4-6

The orthogonal position also has been tried in a clinical setting that uses flat panel detectors. In this setting, the position is easier to obtain because lateral imaging plate holders and upright detectors can be manipulated into many positions (see Figure 6). Moreover, departments with tilting upright Bucky trays can more readily position patients this way. The position also can be done with the patient standing.

**Discussion**

Radial head and neck fractures account for an estimated 25% to 44% of all elbow fractures and 1.7% to 5.4% of all fractures in adults; 85% of radial head fractures occur in patients between 20 and 60 years old.10-13 Thus, great care should be taken to avoid missing radial head and neck fractures. The research in this study shows that technologists can offer similar results with orthogonal and traditional methods. A 45° CR/image receptor orthogonal approach is innovative and easily can be added to a radiographer’s repertoire. The Coyle method uses a single 45° angle and should be used when the situation warrants.

A disadvantage of the orthogonal method is that it cannot be used when the joint is flexed. However, the radial head fracture discussed in the clinical trial section shows that the orthogonal approach can be used in a partially flexed joint. Another disadvantage is related to the type of equipment used when performing the exam. Technologists from departments with floor-mounted tube stands found this position cumbersome and more time consuming than the traditional method. Likewise, technologists sometimes found it problematic to find sponges and accessory items needed to support the arm.

Future studies could investigate this orthogonal approach with other exams. For example, an oblique of the hand, wrist, and ankle should render the same appearance as the external oblique performed with the traditional rotational method.4-6

**Figure 5.** A radiography student model demonstrates the 45° CR/image receptor orthogonal approach clearly demonstrates a radial head fracture. The patient could not extend his arm completely, but the efficacy of the exam remained intact.

**Figure 6.** A radiography student model demonstrates the 45° CR/image receptor orthogonal position. A. Wireless detector placed in a mobile lateral cassette holder. B. The model demonstrates the position in a rotating upright Bucky.
results by tilting both the CR and the image receptor while the patient maintains a fixed position. In addition, studies using lateral detector holders and upright Bucky trays could be used to expose a variety of recumbent patient positions. Furthermore, the orthogonal approach could be investigated with the Clements-Nakayama method of the proximal hip and axillary views of the shoulder. Positioning textbooks might include CR angles, required projections, and the direction of the CR needed to obtain the desired result. Similar projections might be a good addition to a trauma chapter. At the least, textbooks should demonstrate positions like this to stimulate critical thinking. Regardless, wireless detectors and portable detector holders will lead to innovative and viable approaches to traditional positioning methods.

Conclusion

The 45° CR/image receptor orthogonal approach is easy to perform and offers quality images. Technology is rapidly changing, and innovative approaches to traditional methods can alleviate awkward and painful maneuvers for the patient without disrupting the integrity of the study. Thinking intuitively can alleviate painful positions and provide nontraditional but similar results. This orthogonal approach can be adapted at most clinical sites. Technologists should be encouraged to think of innovative ways to accomplish the same tasks while improving patient satisfaction and comfort.

Casey Jackman, MVH, is the director of ancillary services for Mountain View Hospital in Idaho Falls.

References

Carotid Vessel Evaluation Via a 3-D Workstation

Norman Gellada, R.T.(R)(CT)

Carotid stenosis is a common disorder that can lead to hemodynamic compromise. Therefore, vessel evaluation in patients with suspected carotid stenosis or related pathology is crucial. Computed tomography scans of good diagnostic quality are not always sufficient, and the software used to analyze the vessels might not adequately identify the region of interest. This article reviews basic anatomy, common pathologies, carotid vessel analysis, and steps to correct automated processing failure.

Anatomy

Three main vessels stem from the aortic arch: the brachiocephalic artery (also called the innominate artery), the left carotid artery, and the left subclavian artery. The right subclavian artery and the right carotid artery branch off from the brachiocephalic artery. The common carotid arteries supply blood to the head and neck. Each carotid artery divides into 2 branches: the external carotids, which supply blood to the exterior of the head, the face, and the greater part of the neck; and the internal carotids, which supply blood to the brain and structures within the cranial and orbital cavities (see Figure 1).1

Common Pathology

Common pathologies encountered during vessel probe include stenosis, aneurysm, and dissection. Stenosis is the narrowing of the vessel lumen that can be caused by a lesion (see Figure 2). Stenosis can restrict the blood flow to the brain and lead to carotid occlusion. Common treatments for symptomatic patients with greater than 50% stenosis are stent placement or carotid vascular surgery (also called carotid endarterectomy). Aneurysms occur when the wall of the vessel weakens and dilates (see Figure 3). If an aneurysm ruptures, blood will leak into the structures around the brain. Coils and stents are used to treat internal carotid artery and cerebral artery aneurysms.2 Dissection...
is the separation of the layers of the vessel wall (see Figure 4). Dissection generally is caused by trauma to the vessel and is one of the most common causes of stroke in young adults. Endovascular stent placement is the treatment of choice for patients diagnosed with carotid dissection.³

**Vessel Evaluation Software**

Vessel evaluation software helps provide clear and accurate diagnostic information. It also displays multiple-angle and 3-D views of the vessel rather than only the standard axial, coronal, and sagittal planes (see Figure 5). The software also allows visualization of tortuous or bent vessels (see Figure 6) and evaluation of the percentage area of stenosis (see Figure 7). A limitation of the software is that it sometimes has difficulty evaluating the region of interest.

**Measuring Stenosis**

Reference sites measure the degree of diametric stenosis differently. For example, to determine the percentage of diameter stenosis in an internal carotid artery, the North American Symptomatic Carotid Endarterectomy Trial uses the formula 1 − (a/c), where a is the residual luminal diameter at the stenosis and c is the luminal diameter at a visible, disease-free point above the stenosis. These findings are important to patient treatment, so the radiologist should note the reference site used for quantification.⁴

The software tracking algorithm is based on Hounsfield units (HU). To track the vessel effectively, contrast opacification must be greater than 300 HU with the absence of any artifacts. When it comes to scans that have fewer than 200 HU in contrast enhancement, automated vessel analysis is proficient but not 100% reliable. The chance of a good evaluation of the vessel will vary depending on scan quality. Indication of a vessel analysis failure results in an image like the one in Figure 8A.

Correcting a failed vessel analysis can be a tedious task and might involve editing the vessel lumen every 1 mm to 3 mm. The process takes a significant amount of time depending on the type of software failure. Manual processing is required to measure the vessel lumen diameter accurately. Hardware, poor contrast opacification, motion, plaque, and patient...
Figure 5. A zero and 90° window of the probed vessel (A) and minimum diameter curved display window (B).

Figure 6. Green arrows point to the tortuous area of the carotid artery in 3-D volume rendered and curved reformation.

Figure 7. Minimum diameter curved display window with lesion measurement tool to calculate stenosis.
size all affect the amount of manual correction needed. Manual postprocessing can greatly improve vessel evaluation on a suboptimal study and increase accuracy.

What To Do When a Vessel Probe Fails

A vessel probe failure will result in off centerline tracking, meaning that instead of following the region of interest (carotid vessel lumen), it can jump to the nearest area that is not of interest. This could result in a pseudo-occlusion and, thus, a misinterpretation of the study. When a vessel probe fails, the first step is to correct the centerline. Once the area of interest is selected, the centerline can be corrected by using curved multiplanar reformation as a reference. After the vessel centerline has been established, the vessel lumen can be corrected (see Figure 8). Editing time will vary depending on the quality of the scan. The radiologic technologist should scroll through each image and correct the lumen (see Figure 9).

After lumen correction is complete, the lesion measurement can be completed and documented. Editing the centerline and lumen when an automated vessel probe fails should provide a more accurate measurement.

Figure 8. A failed vessel probe. The centerline is off, resulting in a pseudo-occlusion (A). The centerline has been corrected through editing (B).

Figure 9. Failed vessel track resulting in an incorrect lumen diameter measurement (A). Lumen diameter after correction (B).
of the vessel lesion. Workstation centerline and lumen editing software vary depending on an institution’s vendor, so individuals should become familiar with the software available at their facility.

Conclusion

Occlusions, aneurysms, and dissections in vessels that supply blood to the brain are serious conditions. Acquiring a computed tomography angiogram with vessel evaluation quantification software is the first step in determining the patient’s risk factors. Automated vessel evaluation is helpful in defining those risks, but manual postprocessing still could be necessary. Knowing how to fix potential issues derived from automated vessel evaluation reduces patient risk and offers a more accurate diagnosis.

Norman Gellada, R.T.(R)(CT), is an imaging technology specialist focusing on advanced 3-D postprocessing procedures at S Mark Taper Foundation Imaging Center, a division of Cedars Sinai in Los Angeles. He is also a junior PACS administrator at the institution. He previously held a floor supervisor supply officer role at Robert E Bush Naval Hospital in Twentynine Palms, California. Norman Gellada was a recipient of 3 commendations and was selected as Junior Sailor of the Quarter during his naval career. He graduated with honors from the Naval School of Health Sciences, specializing in advanced radiography.

References

Educational programs accredited by the Joint Review Committee on Education in Radiologic Technology (JRCERT) undergo periodic reviews that include on-site evaluations. Here is the scenario: You are the program director for an educational program. The site visitors come to your institution, complete the evaluation, and provide feedback to the JRCERT. You receive your findings report and learn that your program is being cited for Standard 1, Objective 1.2, which states that every program must provide equitable learning opportunities for all students (see Box).1 Bewildered, you continue reading and discover that 2 female students at a clinical site were rotating through the breast center, observing mammography. A male student was there also, but he was not allowed that opportunity. To comply with Objective 1.2, you need to resolve this gender inequity within 6 weeks.

You must respond to this citation, and you do not want to meet the objective by eliminating the opportunity for female students to observe mammograms. Should male students be allowed to observe mammography, as well? The JRCERT Board of Directors believes they should. A mammography rotation is a valid and valuable experience for all students, and we encourage program directors to keep mammography rotations in the educational program and open to all students.

Reviewing the Research

Recent research in the area of patient attitudes toward male mammographers is limited. A 2008 study in Ireland — where all mammographers are women — surveyed women who were recently screened for breast cancer. Of the 1716 responses received, 8.8% of women would refuse the mammogram if the radiographer were a man, and 8.9% of respondents would have the exam if the radiographer were a man only if a female chaperone were present.2 Conversely, 82.3% of surveyed women would have proceeded with the mammogram conducted by a male radiographer, even though 44.9% would have preferred a female radiographer or chaperone.3

Prior to this study in Ireland, much of the previously published work was conducted in the United States during the 1990s. A 1993 study conducted with 180 women at a Denver clinic reported that 75% would not object to a qualified male mammographer.4 A study conducted in Indiana in 1994 surveyed 1000 women undergoing screening mammography.

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Box

JRCERT Objective Addressing Equitable Learning

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<th>Objective 1.2</th>
<th>Provides equitable learning opportunities for all students.</th>
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<td>The provision of equitable learning activities promotes a fair and impartial education and reduces institutional and/or program liability. The program must provide equitable learning opportunities for all students regarding learning activities and clinical assignments. For example, if an opportunity exists for students to observe or perform breast imaging, then all students must be provided the same opportunity. If evening and/or weekend rotations are utilized, this opportunity must be equitably provided for all students.</td>
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Participants were asked their opinion about male technologists and students performing the exam. Although respondents indicated a high preference for female technologists, a majority said they would complete the examination with a male technologist. Most women did not object to female or male students participating in the exam. The survey showed that women’s opinions were not strongly influenced by the sex of their personal physician, their age, or their previous mammography experience.  

Incidentally, a 2007 survey of male nurses found that 58% of respondents had not experienced gender bias during the nursing program. Those who did experience gender bias (42%) reported that it came from nursing faculty and nursing staff, not from patients.

Women are allowed to prepare male patients for barium enemas, do testicular ultrasounds, and assist with urethrogram on men. Male nurses are allowed to place urinary catheters in female patients as long as the patient consents. Why should a mammography rotation be different?

Communication Is Key

Clinical instructors should be aware that mammography is covered in most educational programs’ curriculum and that all students are taught the procedure. Program directors are responsible for providing learning opportunities in advanced imaging modalities that include patient preparation, risks, and diagnostic advantages. Although clinical rotations in mammography are encouraged to enhance student learning, many clinical instructors do not allow male students to participate in mammography rotations at their facilities.

Communication with these instructors is crucial. Use these 3 talking points when discussing mammography rotations with them:

- Men can develop breast cancer and might require mammography or ultrasound for a diagnosis.
- Many female patients are accustomed to male physicians, so these patients may not be uncomfortable if a student of either sex observes their mammogram, as long as they are asked in a professional manner.
- Orienting new employees to mammography is easier if the graduate is exposed to this clinical rotation during an educational program.

Educational program directors and instructors in the clinical setting should understand the benefits of an equitable educational program that allows male students to complete a rotation in mammography.

Finding a Solution

An educational program that allows students to select a few rotations in advanced imaging modalities during the last couple of semesters should have at least one site that agrees to allow male students to observe mammography, if the student requests it. Every clinical setting affiliated with the educational program does not have to allow it, but providing at least one facility that does, offers male students an equal opportunity.

Let’s say a program asks students their preferences for modality rotations, and a male student selects radiation therapy and ultrasound while a female student selects mammography and interventional radiography. This is equitable as long as both students have the opportunity to select any of those 4 options. If the male student selected mammography, he might have to relocate to a different clinical site for that rotation, but the option was available, and the educational program met Objective 1.2.

The JRCERT staff and Board of Directors hope educational programs can make equal opportunities available for all students. Students should receive a solid clinical education and clinical experience in mammography.

Debra Poelhuis, MS, R.T.(R)(M), has served as program director for Montgomery County Community College since the radiography program’s inception in 2003. She has been in radiography education for 33 years, 23 of those as a program director. She has clinical experience in CT, mammography, forensic radiography, trauma radiography, and interventional radiography.

She has presented professionally at the local, state, and national levels and has coauthored a textbook in radiography and another in nursing. The Indiana Society of Radiologic Technologists granted her the Distinguished Service Award as president in 1992, Technologist of the Year in 1996, and Life Membership in 1997.

Poelhuis has served 4 years on the JRCERT Board of Directors, and she is currently the first vice chair.
References


Delayed Energy Release by Selenium-based Detectors

Thomas G Sandridge, MS, MEd, R.T.(R)

Amorphous selenium-coated flat panel detectors are a common component in today’s digital imaging systems. Unlike cassette-based computed radiography (CR) image receptors, direct radiography (DR) systems use fixed detectors to receive remnant photons and convert them into electronic signals. Once an exposure is made, an electric signal is generated, followed by an application of voltage to clear the detector, preparing it for its next exposure.

Two rare artifacts associated with selenium-based DR detectors are ghosting and lag effects. Ongoing improvements in digital technology and in manufacturer-developed software are reducing the occurrence of these artifacts, but lag and ghosting still could occur. Although similar in appearance, the causes of these artifacts differ. Ghosting artifacts occur when prolonged or excessive exposures reduce detector sensitivity. This reduced sensitivity may subside over time or may be significant enough to require equipment servicing. Unlike ghosting, lag effects occur when the improper release of a single exposure signal fails to erase the detector completely. Lagging is seen as a faint, residual image superimposed over the subsequent image and is most noticeable in areas of lower exposure.

The Images

A 72-year-old woman who presented with back pain received a scoliosis series performed on Carestream DR Long-Length Imaging equipment. The first series exposure was the anteroposterior (AP) upper, followed in rapid succession by the AP lower. The stitched AP image had a composite exposure index of 1939, which fell within the vendor-recommended range.

Figure 1. Arrows demonstrate the superimposed remnant image of the upper anteroposterior (AP) over the AP lower, caused by detector lag. The image has been enhanced to better demonstrate the artifact.

(see Figure 1). The faint outline of the upper AP image seen superimposed over the lower is likely the result of detector lag due to rapid successive exposures.
The patient was repositioned and the upper lateral projection was obtained, followed in rapid succession by the lower. The stitched lateral image had a composite exposure index of 1152, which fell below the vendor-recommended range (see Figure 2).1–3 Although the lag artifact is no longer visible, the lower lateral projection shows a faint superimposed outline of the upper lateral image. Again, minimal time between exposures likely contributed to the appearance of the fading image, as insufficient time had elapsed to allow the detector to clear completely. Because the lower lateral projection shows a faint superimposed image of the upper lateral, the technologist likely made the second exposure the moment the ready light appeared.

Because the initial superimposed image of the upper AP did not persist onto the lateral, lagging is likely the artifact demonstrated. Ghosting would have persisted, projecting a faint AP image onto the subsequent lateral projections. Although the patient received a repeat examination, the radiologist’s preliminary report referred to the exam as a “technically limited study with multiple artifacts,” noting “superimposition of the head and neck onto the abdomen.”

The imaging department’s technical coordinator recommends a wait time of a few seconds after the ready light appears before making another exposure. This practice should eliminate residual image signals without adversely affecting workflow. If this action does not resolve the issue or the artifact occurs frequently, the equipment might require upgraded software to minimize the effects of detector lag.2,4

Thomas G Sandridge, MS, MEd, R.T.(R), is a regular contributor to Radiologic Technology’s Technical Query column and is the program director for the School of Radiography at Northwestern Memorial Hospital in Chicago.

References

If you missed Sandridge’s assessment of “Quantum Mottle and Exposure Indices” in the CT version of the July/August Radiologic Technology journal, check it out at www.asrt.org/publications.
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A 23-year-old woman presented with a diastasis symphysis pubis. The condition, also called symphysis pubis dysfunction, results when normally joined pubic bones dislocate. Although rare, it can occur late in pregnancy or during delivery as a result of hormones relaxing the ligaments or biomechanical factors. Symptoms range from mild discomfort and difficulty walking to total incapacitation. Treatment usually includes rest and oral analgesics; severe cases could require surgery. Image courtesy of Gonstead Family Chiropractic, Albuquerque, NM.

You Might Have Missed...

[M]any clinical instructors do not allow male students to participate in mammography rotations at their facilities.

Separation Anxiety

A 23-year-old woman presented with a diastasis symphysis pubis. The condition, also called symphysis pubis dysfunction, results when normally joined pubic bones dislocate. Although rare, it can occur late in pregnancy or during delivery as a result of hormones relaxing the ligaments or biomechanical factors. Symptoms range from mild discomfort and difficulty walking to total incapacitation. Treatment usually includes rest and oral analgesics; severe cases could require surgery. Image courtesy of Gonstead Family Chiropractic, Albuquerque, NM.
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