

# Promoting Radiation Safety Protocols in Computed Tomography

Leslie Ann Bell, R.T.(R)(CT)

In recent years, use of computed tomography (CT) has increased dramatically. Increased dose from radiography, and CT in particular, has led many physicians and patients to question the cancer risks and overall safety of modern imaging. It is essential for radiologic technologists to be properly trained and certified in CT and to understand technical factors and how they are related to radiation dose and image quality. Keeping radiation doses as low as reasonably achievable (ALARA) and maintaining clear communication with the patient is essential to produce quality images and reduce radiation exposure. In addition, physicians must receive proper training in radiation safety to follow through on their promise to “do no harm.” The health care team has the opportunity and responsibility to improve the lives of patients, which includes eliminating unnecessary radiation dose.

CT has changed the way health care is delivered over the past 40 years. The need for exploratory surgery has been dramatically reduced and countless lives have been saved because of information gained from CT scans. Quick image acquisition using CT has allowed doctors to discover life-threatening conditions in a matter of seconds. It is an invaluable tool that has improved the lives of thousands of patients.

However, many consider this technology to be a double-edged sword; in recent years some have raised concerns that CT is being overused. In busy emergency departments, CT is the modality of choice, even when

ultrasonography or a magnetic resonance scan might be more suitable and safer for the patient.

## Radiation Risks

Radiation doses vary widely because of factors such as body habitus, pathophysiology, scanning protocols, and technical factors. Although some of these factors are out of the radiologic technologist’s control, CT radiation dose can be reduced. In 2009, the U.S. Food and Drug Administration (FDA) raised concerns about excessive exposure from CT imaging and urged clinicians and manufacturers to implement protocols to reduce radiation dose.<sup>1</sup>

Ionizing radiation causes damage at the cellular level. When x-ray photons pass through human tissue, ion pairs are formed. Interaction between ionic pairs and DNA can cause irreversible damage to the DNA. Damage from radiation also can occur through direct contact between x-ray photons and the DNA bonds within the nucleus.<sup>2</sup> A 2009 study from the National Cancer Institute estimated that CT scans performed in 2007 will cause a projected 29 000 cancer diagnoses and 14 500 untimely deaths for those exposed to excessive radiation. A British study tracked children who received multiple CT scans and concluded that these children were 3 times more likely to develop leukemia and brain cancer in their lifetime.<sup>3</sup>

A 2007 survey of emergency department physicians found that 91% significantly underestimated radiation

dose from CT scans. Many ordering physicians have little or no training regarding radiation exposure in medical imaging, which contributes greatly to patient radiation exposure. Many physicians order CT scans before seeing the patient, and rarely does the radiation dose factor into their decisions. In many cases, nurse practitioners and physician assistants order CT scans without hesitation.<sup>5</sup> These practices and lack of knowledge have contributed to the widespread use of CT even when nonionizing alternatives exist. In fact, CT has begun to replace conventional radiography as the standard diagnostic examination.<sup>4</sup> In 1980, 3 million CT scans were performed in the United States. By 2005, that number had risen to 60 million.<sup>5</sup> Often, fear of medical error is considered reason enough to order a CT scan. Physicians should receive proper training in medical school about the risks of excessive radiation exposure. The potential benefit of such training to patient safety is significant.

The trend of ordering excessive CT scans is alarming: according to the National Council on Radiation Protection & Measurements (NCRP), the dose from a single CT scan can be 100 to 1000 times higher than a routine radiograph.<sup>3</sup> Although most radiologists agree that a diagnosis can be made without an additional non-contrast CT scan in most cases, *The Washington Post* reported that nearly 1 in 6 hospitals in Virginia still performed double scans.<sup>6</sup> Eliminating this practice except in rare instances can cut a patient's radiation dose by half and reduce costs. Standardization of CT protocols is key to eliminating unnecessary radiation and ensuring that patients receive the most appropriate imaging examination.

### Standardization of Protocols

The American Association of Physicists in Medicine (AAPM) has been instrumental in the effort to standardize CT protocols. Creating guidelines that can be implemented in all medical facilities can ensure patient safety. The AAPM has appealed to Congress to create regulations to ensure Americans receive the most appropriate test and at the lowest radiation dose possible. The AAPM also is leading the campaign to ensure that all imaging centers and hospitals are accredited.<sup>7</sup> Along with the AAPM efforts, the FDA's *Initiative to*

*Reduce Unnecessary Radiation Exposure from Medical Imaging* stresses the need for standardization in optimal patient dose. Unnecessary radiation can come from using higher than normal radiation doses to produce better images, but these better images are not always necessary to make an accurate diagnosis. However, if the dose is too low, the resulting images might not be diagnostic, which could result in additional imaging and increased dose.

The FDA has raised concerns over the variation in radiation dose observed across several facilities in the San Francisco Bay area. Variations in dose demonstrate the need for dose optimization and standardization, especially when imaging children. The FDA, AAPM, NRC, and the American College of Radiology (ACR), are working together to establish nationally recognized diagnostic reference levels (DRL) for CT.<sup>8</sup> A DRL is an effective method for minimizing dose and variance between facilities at a minimal cost to radiology departments. It also serves to make technologists more aware of the radiation dose they deliver. With DRLs, technologists are more equipped to answer patients' and physicians' questions about dose.<sup>9</sup> In addition, the ACR and the American College of Cardiology have developed a guide for ordering physicians called the Appropriate Use Criteria. This is an important tool physicians can use to decide which imaging modality is the most appropriate.

Oversight of medical devices is another crucial component of standardization. The National Electrical Manufacturers Association Standard XR-29-2013 (also known as the MITA SmartDose Standard) requires manufacturers to equip CT scanners with safeguards. Safeguards include a display and record of radiation dose and the capability to alert the technologist if the dose exceeds the recommended reference value.<sup>10</sup> Preloaded adult and pediatric scan protocols allow the technologist to follow a standard process, and automatic exposure control functions are an integral component.<sup>1</sup>

### Radiation Safety and Awareness

Dose is influenced by several parameters controlled by the technologist, including scan time, milliamperes seconds, kilovoltage peak, slice thickness, anatomical coverage, and pitch. Employing safe imaging par-

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ameters is the responsibility of the CT technologist<sup>1</sup>; it is crucial that he or she understands the relationships between imaging parameters to properly implement ALARA in each examination. Scan parameters must be adjusted according to patient size. Smaller patients should have milliamperere seconds reduced. Providing technologists with a set of guidelines for milliamperere seconds selection as a function of patient size would be helpful. In addition, cardiac CT dose can be reduced dramatically if the milliamperere seconds are reduced during the suboptimal phase of the cardiac cycle in a gated examination.<sup>10</sup>

The AAPM, the Society for Pediatric Radiology, the ACR, and the American Society of Radiologic Technologists (ASRT) have made it their mission to increase awareness and reduce radiation dose to children through the Image Gently campaign. In addition, the Image Wisely campaign aims to ensure appropriate imaging by educating physicians who order medical imaging examinations. The Image Wisely campaign also is instrumental in providing patients with accurate information and an imaging record card developed in partnership with the FDA.<sup>7</sup>

Lead shielding is the simplest way to reduce exposure during diagnostic imaging and should be applied anteriorly and posteriorly because of the rotational nature of CT scanning. Bismuth shields can be used in the scan field of view to reduce radiation to the breast, thyroid, and the lens of the eye. It is crucial to obtain the localizer CT radiograph before applying bismuth shielding. The scout image, which estimates patient attenuation, will respond to shielding by increasing milliamperere seconds if shielding is applied before the scout image is taken.<sup>11</sup> Breast tissue is highly radiosensitive, and studies have shown female atomic bomb survivors had a greater risk of developing breast cancer.<sup>12</sup> Young women who have undergone radiographic examinations for scoliosis also have shown an increased incidence of breast cancer.<sup>12</sup> Studies also have shown that in-plane bismuth shielding can reduce radiation dose to breast tissue by up to 37%.<sup>12</sup> Radiology departments should develop their own mandates regarding shielding.

Effective communication with the patient is an important step in reducing radiation dose. Poor communication can result in adverse outcomes, contribute

to confusion, and create an unpleasant experience for the patient.<sup>13</sup> Anxious or confused patients might not follow instructions, which could result in the need for a repeat scan. Obtaining a detailed medical history before an imaging examination can reveal contraindications and prevent medical errors, especially when administering intravenous contrast agents. In 2009, the Pennsylvania Patient Safety Authority reported that patient misidentification accounted for 30% of radiology adverse events.<sup>14</sup> This is due in part to the challenges of electronic medical records and digital imaging services that display images and report instantly before errors might be realized.<sup>14</sup> In a busy CT department, it is crucial that a strict set of guidelines be followed to avoid these errors. These guidelines should include a time out to verify the correct patient, procedure, lab values, allergies to intravenous contrast agents, and purpose of the examination. In addition, staff must verify the anatomical area of interest and the correct timing for bolus tracking. Patients must be informed of the possible harmful effects of radiation, especially in non-emergency situations.

Researchers from the University of Washington School of Medicine in Seattle performed a study on 235 patients at a large academic medical center from February 2011 to December 2011. They found that 34% of patients were not aware that CT imaging exposed them to ionizing radiation. Of the 154 patients who knew they were exposed to radiation, 85% underestimated the amount of radiation they received. Only 5% understood that CT imaging would increase their lifetime risk of cancer. This study suggests that most patients do not have enough education about ionizing radiation to make informed decisions about undergoing medical imaging. Also, some patients might not be able to reasonably assess the potential risks and benefits, even with an explanation by an informed practitioner.<sup>15</sup>

### Solutions

Steps must be taken to protect patients from excessive radiation. A survey of 435 emergency department physicians showed that 97% admitted to ordering CT scans that were not medically necessary because of the threat of possible lawsuit.<sup>16</sup> A “safe harbor” law

would protect physicians from lawsuits so long as they were following evidence-based guidelines. In addition, hospitals could provide feedback to their emergency department physicians about the number of advanced imaging examinations they are ordering compared to their colleagues.<sup>16</sup>

Clinical decision support is necessary to help physicians choose the most appropriate test for each patient. Having emergency department physicians consult with a radiologist also could decrease the number of CT scans ordered. In many cases, a radiologist might prefer magnetic resonance imaging, sonography, or routine radiographs over a CT scan.

In addition, the radiologist must decide on the most appropriate scanning protocols and methods of radiation protection. Although the FDA has played an instrumental role in creating guidelines for CT scanners, no regulatory oversight for how they are used exists.<sup>3</sup> Further regulation of the modality is critical.

Prior authorization for CT scans might be a necessary component of legislation to reduce the number of unnecessary scans. Prior authorization for advanced imaging services is widely used by private insurance companies but has not been adopted by Medicare.<sup>17</sup>

Patients also need to play an active role in their health care decisions and should be educated regarding the radiation dose of CT scans. Physicians must take time to discuss risks and benefits with their patients and alternatives to CT scanning. Patients also should be provided with a card to record their medical imaging history and a CD of the examination's results when possible.

## Conclusion

CT is an invaluable tool that has revolutionized health care. However, physicians, imaging professionals, and patients must be aware of the cancer risk associated with overuse of this modality. Research clearly shows a link between radiation exposure and cancer.<sup>12</sup> Radiologic technologists must be diligent to do no harm to patients and apply ALARA principles to each and every examination. Physicians base their imaging decisions on what is in the patient's best interest, and they must be educated about the risks of CT to make that decision. Education in radiation safety is

essential, and transparency regarding radiation dose should be mandatory. Employing safety regulations and standards might reduce future cancer diagnoses and reduce health care spending.

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*Leslie Ann Bell, R.T.(R)(CT), is a computed tomography technologist for Bert Fish Medical Center in New Smyrna Beach, Florida.*

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