
Radiation Safety in the Modern Radiology Department: A Growing Concern

G Marshall, S Keene

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Abstract

The number of diagnostic radiology procedures performed in the United States continues to grow each year. With this growth, there should be a concern to keep radiation dose as low as reasonably achievable. The purpose of this research paper is to reiterate the importance of radiation protection in the radiology department. Recent studies of 146,022 certified radiologic technologists indicate radiation workers may be at a greater risk of developing breast cancer or leukemia. Receiving a dose as low as 1 rem may increase a person's chance of developing cancer by 1 in 2000. Computed radiography and tomography equipment now make it possible to overexpose the patient without having to repeat the exam. Even though new radiology equipment has drastically improved in image quality and speed in the last few years, it is now much easier to expose patients to excessive amounts of radiation.

INTRODUCTION

The first radiation fatality occurred in 1904, just nine short years after X-Rays were first discovered by Wilhelm Roentgen. By 1910, there had been hundreds of cases of severe X-ray burns, some leading to death. It took the X-Ray community more than 30 years from the time of Roentgen's discovery to start practicing basic radiation protection (Bushong, 1991).

There seems to be a general disregard for basic yet, essential radiation safety practices in the new "digital age" of Radiology. While there has been much recent advancement in diagnostic radiology equipment concerning speed and imaging quality, there has been little or no improvements concerning the radiation dose limiting aspects of this equipment. Today's equipment makes it much easier for a technologist to repeat an exam unnecessarily, and allows them to overexpose the patient without having to repeat images.

New studies concerning computed radiography show that standard exposures can and should be reduced by as much as 50% without compromising imaging quality (Gregoire, 2006). Computed tomography usage has grown significantly in the last several years. The new 16 and 64 slice computed tomography scanners are capable of delivering a significant dose of radiation to the patient in one single scan. New radiation exposure risk data should remind each radiologic

technologist to keep radiation doses to themselves and their patients as low as reasonably achievable.

REVIEW OF LITERATURE

It is known that X-Ray radiation is harmful. The effects of ionizing radiation can either be classified as stochastic (random) or deterministic (nonrandom). Through radiation protection, deterministic effects may be prevented and stochastic effects may be reduced. Radiation dose from diagnostic procedures is controlled by government agencies because of the risks associated with stochastic effects (Koehler & Natarajan, 2007). All modern radiation protection guidelines are based upon the linear dose response model without a threshold. This model states that as radiation dose increases, radiation risk also increases, and there is no threshold. Because stochastic effects have no identified threshold, even small doses may cause biological harm. Hereditary effects, cancer, and leukemia are some examples of stochastic effects (Seeram, 1999).

Radiation absorbed dose (RAD) is the unit of absorbed energy or dose. This unit is applicable to any type of material; however some types of radiation such as alpha and beta particles produce more biological damage than X-radiation or gamma does. In order to account for the same radiation absorbed dose causing different biological effects, the rad equivalent man (REM) was developed. The REM is the product of the quality factor assigned to a given type of

radiation and the absorbed dose in RADs. The quality factor for X-radiation is one; therefore 1 RAD of X-radiation equals 1 REM of X-radiation (Rossi, 1992).

Maximum permissible dose was a term used in the past to describe the maximum dose of radiation that was felt to be safe for an individual to receive. The term maximum permissible dose is no longer used today because no dose is considered permissible. The principle of keeping each individual's dose as low as reasonably achievable (ALARA) is now used, and the National Council on Radiation Protection (NCRP) recommends radiation dose-equivalent limits. Prior to 1987, the formula $5(N-18)$ rem, where N equals the age of the radiation worker in years, was used to formulate the maximum lifetime whole-body dose equivalent. In 1987, the NCRP established new recommendations for maximum whole-body dose equivalent. The new formula of 1 REM X age in years, reduces the amount of radiation a worker may receive over their lifetime (Jefferies, 1994). Studies show as the recommended maximum dose has been decreased, radiologic technologist's exposure has decreased as well. Technologists in the 1980s received as much as 35 times less radiation exposure than technologists that worked prior to 1939 (Simon et al, 2004).

The cancer risks following radiation exposure have been broadly studied. Most of the information we have today comes from studies of Japanese atomic bomb survivors, studies of radiologists and radiologic technologists from other countries, and from studies of nuclear industry workers (U.S. Radiologic Technologist Study, N.D.). There was a need for new research on chronic low dose radiation exposure because the above mentioned studies yielded inconsistent results. The latest research concerning radiation exposure and cancer risk comes from studies of United States Radiologic Technologists. This study included 146,022 certified radiologic technologists (ARRT) that worked for 2 years or longer between 1926-1982. The findings of this study showed that this group of radiologic technologists was found to have an increased risk for breast cancer and leukemia (Mohan et al, 2002).

A diagnostic procedure with an effective dose of 1 rem may increase a person's risk of developing a fatal cancer by 1 in 2000 (FDA, 2002). This amount of exposure could be delivered to a patient having a routine Computed Tomography (CT) scan of the abdomen, an upper gastrointestinal study (UGI), a barium enema (BE), or an intravenous pyelogram (IVP) (ICRP, N.D.). It would take

approximately 3.3 years to be exposed to this amount of radiation by natural background sources (FDA, 2002). The amount of dose for a given procedure may vary by as much as a factor of ten when performed at different facilities. This can be contributed to legitimate changes in technical factors because of film/screen speed, film processing, and voltage. There is however possibilities for even greater patient dosage than the factor of ten previously mentioned, due to suboptimal performance of the procedures in some facilities (ICRP, 2007). From studying animals exposed to acute and chronic radiation, scientists have concluded that humans can expect to have their life spans reduced by 10 days for every rad received (Bushong, 1993).

Minimizing patient radiation dose without compromising image quality is an important issue in radiology today. There are no dose limits for patients undergoing diagnostic imaging procedures. Through ALARA principles, each exam should be optimized to obtain a quality diagnostic image, while keeping patient dose as low as possible (Seeram & Brennan, 2006).

The three cardinal principles of radiation protection include reducing the time of radiation exposure, keeping as much distance between the source of radiation and the person being exposed, and placing a shielding material between the person being exposed and the source of radiation. The cardinal principles of radiation protection were first created for use in nuclear activities, but they can reduce patient and technologist radiation dose when used properly in diagnostic radiology (Bushong, 1993). Proper x-ray beam collimation, and appropriate radiographic technique selection including kilovoltage power (kVp) and milliamperage-seconds (mAs) should also be utilized to decrease radiation dose (Bushong, 1991).

The new trend in radiography today is computed radiography (CR). CR systems have gradually replaced most conventional film-screen systems (FS) in many parts of the world. CR systems have post processing advantages over FS by being able to correct underexposed or overexposed images without having to repeat the examination. Most CR systems have the ability to correct an overexposed image through image processing algorithms before the image is even displayed. Because of this, the patient may be overexposed without the technologist ever knowing about it. In most CR equipment, there are numerical systems to allow the technologist to know if the patient was overexposed (Brindhavan & Khalifah, 2005). It has been said that some technologists routinely overexpose patients because the

images look very crisp and clear, and they do not get rejected by the interpreting radiologist. This philosophy of imaging goes against ALARA principles (Gregoire, 2006), and against American Registry of Radiologic Technologists (ARRT) standard of ethics. ARRT code of ethics number seven states, “ The radiologic technologist uses equipment and accessories, employs techniques and procedures, performs services in accordance with an accepted standard of practice, and demonstrates expertise in minimizing radiation exposure to the patient, self, and other members of the healthcare team.” (ARRT, 2006). Recent studies have shown that most X-Ray exposures using CR may be reduced by as much as 50%. Also, there is a need for quality control processes that cannot only track technologist repeat rates, but can also pinpoint technologists that are consistently overexposing patients with CR equipment (Gregoire, 2006).

Computed tomography usage has increased by as much as 800% in the last two decades (Hayes, 2007). The increase in CT usage can be contributed to its rapid technological improvements. It is now possible to scan the chest in one single breath hold. While recent advancements have drastically improved image quality, they have come at the price of increase patient radiation exposure in many cases (Rehani& Berry, 2000). CT is now considered a high-dose procedure and has come under much scrutiny in recent medical literature (seeram, 1999). Just a few years ago CT comprised about 2-3% of all radiology diagnostic exams, and at that time contributed about 20-30% to patient radiation dose from all medical radiology procedures. CT may now contribute over 50% of the total dose delivered to the general population from radiological procedures. A CT scan of the orbits can deliver a radiation dose of 1 to 13 rems to the lens of the eye (Rehani& Berry, 2000). Almost 100% of those who receive over 1000 rems of radiation to the lens of the eye will develop cataracts. Also, research indicates that an acute dose of 200 rads of radiation will likewise cause cataracts (Bushong, 1993). The radiation dose distribution of CT is much different than in radiography. This can be contributed to the geometric way in which data is gathered. Typically in radiography the surface of the patient where the X-Ray beam exits gets a substantially less amount of radiation exposure than the entrance surface. In CT the exposure is more spread out due to tube and detector rotation around the part being imaged (seeram, 1999). The new 16 and 64 slice CT scanners are now fast enough to image the coronary vessels with little to no motion artifacts; however it has been reported that the cancer risk associated with this procedure is 1 in 1400 versus 1 in 3600 with a

diagnostic angiogram (Staffey, Van Beek & Jagasia, 2007).

With the simple operator interfaces available on new CT scanners today, it can be very easy to perform a scan on patient without thinking about the radiation exposure that will be given. Much like CR, CT images are digital, and overexposure does not negatively affect image quality. It is now required by law for all CT manufacturers to provide dose tables with new CT scanners. CT technologists should always be looking for ways to keep the dose to the patient as low as reasonably achievable. Some ways to decrease patient dose include decreasing the mAs while keeping kVp the same, decreasing the kVp while keeping mAs the same, increasing the kVp from 120 to 140 and then decreasing the mAs by at least half, and increasing the pitch on helical scans (seeram, 1999).

CRITICAL ANALYSIS

The role and work of the radiologic technologist has continued to evolve since the occupation was created over 100 years ago. The title technician was first used in the early 1900s, due to uneducated and unskilled personnel using trial and error methods to operate unrefined equipment. The title technologist is now used to reflect the education and knowledge required to work safely in the field of diagnostic radiology. A large portion of every qualified technologist's training is the subject of radiation protection. One of the first things taught in radiologic technology programs is the cardinal principles of radiation protection. Every student technologist knows that time, distance, and shielding is very important to them and the patients they serve. Sadly, as time progresses in some technologists' careers, they tend to forget the importance of some of the basic, yet essential radiation safety practices they once learned. It is common place to see technologists holding patients during procedures, a practice clearly taught against in radiologic technology education programs and in medical literature. Also, technologists may sometimes be seen in procedure rooms during exposures without even wearing a lead apron. New imaging technologies now make overexposing the patient the quickest way to complete a procedure. Clearly, the field of diagnostic radiology is changing, putting pressure on technologists to produce quality images in very short periods of time, which can lead to technologists putting themselves or others in harm's way. Administrators and managers need to be aware that this may occur if a facility is not staffed properly. Technologists, regardless of position, should continue to earn the title “technologist” by making sure the radiation dose to themselves and others stays as low as

reasonably achievable.

CONCLUSION

The field of diagnostic radiology continues to grow in terms of number of procedures performed, types of imaging procedures or modalities used, and number of technologists working in the field. While the amount of radiation exposure to the technologist has decreased drastically in the last two decades, the amount of radiation exposure the patient receives in a given procedure has potentially increased. New technologies allow for patients to be overexposed routinely, and also allow for repeats to be taken quickly, making it easier for a technologist to multiply the patient's dose without considering the implications. Since there is no safe dose of radiation, it is more important than ever to remember and practice the ALARA principle.

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Author Information

Gary W. Marshall, RT (R), (CT), (ARRT)
East Tennessee State University

Shane Keene, MBA, RRT-NPS, CPFT
East Tennessee State University