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Medical Radiation Exposure: A Shared Responsibility

By Andrew G. Moran MD

Introduction

Throughout its history, the specialty of Radiology has prided itself on its innovation and adaptiveness, continually seeking to pioneer new imaging techniques and work together with clinicians to develop safe, effective diagnostic tools and therapeutic advancements. The effect of this partnership has been quite successful, ultimately resulting in a higher standard of patient care and improved clinical outcomes. However, even with these advances, a new challenge has become apparent, facing both radiologists and referring physicians alike. Medication radiation exposure, once an afterthought in adults, has in the past decade gained the attention of the scientific community and more recently been thrust into the spotlight by the national media. While the American College of Radiology has recognized the issue for quite some time, the recent media coverage has fueled a resurgence of interest at both the local and national levels from individual physicians and patients to organizations such as the International Council of Radiation Protection (IRCP) and the American Cancer Society.

Quite justly, the focus of attention has been on the use of CT (computed tomography) scans, which provide substantially higher doses of ionizing radiation than many other forms of diagnostic imaging, up to 50-400 times the dose of radiation incurred as with a conventional PA and lateral chest radiograph. Since its introduction in the early 1970's, the use of CT in diagnostic imaging has exponentially grown, with an estimated 150,000 CT scans currently performed each day in the US and a total of 60-65 million each year. The net effect of this explosive growth in CT has been a dramatic increase in radiation exposure to the population, which in the past two decades has increased greater than 600% or roughly the equivalent to the total collective dose generated by the Chernobyl nuclear disaster.

Radiation Exposure (The Basics)

At the heart of the issue with regards to this increase in medical radiation exposure is the potential for the development of cancer. Ionizing radiation, which occurs at a natural background level of 0.01 mSv per day at sea level (3.6 mSv per year), is thought to induce carcinogenesis by directly damaging DNA or producing toxic hydroxyl radicals in tissue which in turn can damage DNA, resulting in genetic mutations that can form cancers. While we are all exposed to low levels of naturally occurring radiation throughout our lifetime and have sophisticated cellular surveillance to seek and repair this damage, it makes sense that the higher the exposure level and cumulative dose over time may eventually result in an increased risk to overwhelm our protective mechanisms and potentially induce cancer.

The controversy amongst scientists and medical physicists is that it is impossible to predict what exposure level will ultimately generate carcinogenesis, as these effects follow a linear no-threshold model (Stochastic effect). This means that although there is no threshold level for these effects, the risk of an effect occurring increases linearly as the dose increases. Thus, every individual in a population is likely to have a different risk with many genetic and environmental factors playing a role, including unique differences in the body's defense mechanisms. The timing of exposure also plays an important role, with pediatric patients being much more sensitive to these cumulative effects of radiation over time due to increased radiosensitivity of their cells and tissues. Unlike other research in medicine, where controlled clinical trials can be performed, much of the data regarding radiation exposure and its potential carcinogenic effects comes from retrospective studies of atomic bomb survivors where research found a statistically significant increase in cancer development at exposure levels greater than 50-100 mSV. Considering that many CT scans have effective doses in the range of 10-30 mSV and that many patients undergo multiple CT examinations throughout their lifetime, it is not difficult to understand the recent concern in both the scientific and medical communities regarding the overall impact of medical radiation exposure within the population.

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Recent Controversy in Medical Literature: Population Risk vs. Individual Risk

While initial studies published by the National Research Council (NRC) and New England Journal of Medicine estimated that radiation-induced cancer rates associated with CT scans throughout the population were in the range 1.5 to 2 percent, the findings of a more recent Stanford study examining Medicare claims from 1998-2005 suggested that the relative risk to the population may be overestimated. In the study population used by Stanford, CT scans were associated with only a 0.02 to 0.04 percent higher risk of cancer. Regardless of the differences, this only serves to highlight an important factor critical to the discussion of medical radiation exposure: Population risk vs. Individual risk. While the recent media coverage has been focused on the reports regarding the population risk of developing radiation-induced cancers, the more practical issue facing patients and referring physicians in everyday life is defining an individual's risk in relationship to their medical radiation exposure. To do this, it is first necessary to have a basic understanding of what constitutes background and medical radiation exposure.

Background Radiation Risks In Relation to Medical Imaging

As mentioned above, natural background radiation exposure accounts for an average of 3.1 mSv/yr, predominantly from sources such as radon gas and cosmic radiation, with some variation depending on where an individual lives. Living at higher altitudes slightly increases background radiation exposure. An individual living in Denver receives approximately 1.5 mSv/yr more exposure than an individual living at or near sea-level. Frequent air travel can also contribute to an individual's dose, with a single cross country flight adding approximately

Raleigh Radiology is committed to providing all patients with safe and effective imaging.

As part of this commitment, the radiologists and technologists at Raleigh Radiology have all taken the **Image Wisely** pledge, a collaborative effort of several radiologic societies to avoid unnecessary radiation scans and to use the lowest radiation dose for necessary studies. Safe imaging and lower radiation dose begins with protocol oversight and design. Raleigh Radiology in a collaborative effort between CT manufacturers, radiologists, technologists and physicists have implemented several strategies to avoid unnecessary radiation exposure. These include:

- Educating referring doctors about alternative exams (MRI, ultrasound) with lower dose or no radiation
- Ensuring exam is truly clinically indicated
- Using size dependent protocols
- Using tailored low dose pediatric protocols as part of **Image Gently** alliance
- Enabling dose reduction software
- Eliminating multiphase exams when possible
- Using shields, such as breast shields to reduce radiation exposure
- Recording dose of exam
- Establishing radiation dose history for each patient

As a physician, your primary concern is the health, safety and welfare of your patients. By taking advantage of the currently available dose reduction technology and optimizing CT protocols, Raleigh Radiology is able to ensure that your patient's imaging studies are performed with the safest radiation dose possible. When it comes to imaging, one size does not fit all. High-quality imaging in pediatric patients can be obtained with much less radiation, so scan techniques at our practice have been adapted to each child's size. At Raleigh Radiology, we **Image Wisely and Gently**.

Table 1: Radiation Dose Estimates from Common Diagnostic Procedures ***(Source: RadiologyInfo.Org)***

Procedure:	Effective radiation dose:	Compared to natural background radiation for:	Additional lifetime risk of fatal cancer from examination:
ABDOMINAL REGION:			
Computed Tomography (CT)-Abdomen and Pelvis	15 mSv	5 years	Low
Computed Tomography (CT)-Abdomen and Pelvis, repeated with and without contrast material	30 mSv	10 years	Moderate
Radiography (X-ray)-Lower GI Tract	8 mSv	3 years	Low
BONE:			
Radiography (X-ray)-Spine	1.5 mSv	6 months	Very Low
Radiography (X-ray)-Extremity	0.001 mSv	3 hours	Negligible
CENTRAL NERVOUS SYSTEM:			
Computed Tomography (CT)-Head	2 mSv	8 months	Very Low
Computed Tomography (CT)-Spine	6 mSv	2 years	Low
CHEST:			
Computed Tomography (CT)-Chest	7 mSv	2 years	Low
Radiography-Chest	0.1 mSv	10 days	Minimal
WOMEN'S IMAGING:			
Bone Densitometry (DEXA)	0.001 mSv	3 hours	Negligible
Mammography	0.4 mSv	7 weeks	Very Low

0.03 mSv, or roughly the equivalent to a single view chest radiograph. In the US, the average person is exposed to an additional 3.0 mSv/yr from medical sources (predominantly CT scans). Thus, the average US total radiation exposure from all sources is estimated at 6.2 mSv/yr, which is an increase from 20 years ago (3.6 mSv/year) when CT scans were much less common. For comparison, the dose for a standard PA and lateral chest x-ray is 0.1 mSv, and the dose for a standard chest CT is 5-10 mSv.

Medical Radiation Risks: Put Into Perspective

When analyzing the actual risks of developing cancer as a consequence of medical radiation exposure, it is often helpful to put these into perspective by discussing the lifetime risk of death due to other sources. In the United States, it is estimated that the overall lifetime risk of developing an invasive cancer in the population is 37.5% (1 in 3) for women and 44.9% (1 in 2) for men, regardless of imaging history. Note that these statistics do not take into consideration individual risk factors including lifestyle (smoking, diet, exercise, etc) and family history (genetics), which can significantly increase or reduce an individual's risk. In fact, the majority of cancers occur later in life and the average lifetime risk of dying from cancer reported to be 25% (1 in 4).

As an example, a 40 year old woman undergoing a standard abdomen and pelvis CT (14 mSv) would incur a 0.133% additional cancer risk as a result of the CT scan, raising her lifetime cancer risk to approximately to 37.633%. However, put into the perspective of other common risk factors, the same patient would still have an approximately 10x greater risk of dying due to a motor vehicle accident in her lifetime as opposed to having the single CT scan. If that same patient were to undergo an additional 3 abdomen/pelvic CT scans that year (raising the total to 4), the relative risk of developing cancer would increase only to 0.532%, raising her lifetime risk of developing cancer to 38.032%. Again, the same patient would still have an approximately 5x greater risk of dying due to a motor vehicle accident than developing cancer as a result of CT imaging.

Table 2: Estimated Lifetime Risk of Death ***(Various Sources)***

Heart disease	**16.7% (1 in 6)**
Stroke	**4% (1 in 28)**
Motor Vehicle collision	**1% (1 in 100)**
Assault by firearm	**0.3% (1 in 300)**
Drowning	**0.01% (1 in 1000)**
Lightning Strike	**0.001% (1 in 100,000)**

Conclusions

The advent and use of CT scanning in clinical medicine is arguably one of the greatest diagnostic innovations of the past century. It is undeniable that CT scans, when performed properly and in the appropriate clinical context, greatly advance medical decision making and save lives. As with many life-saving medical therapies and interventions, the question is one of potential risks vs. benefits. Taking everything into consideration, it is of utmost importance to realize that the potential health benefits of a CT scan almost always outweigh the potential risks of radiation exposure. Simply put, all of the available scientific data regarding medical radiation exposure clearly demonstrates that clinicians and patients should not hesitate to perform a study if it is medically indicated.

When it comes to medication radiation exposure, it is a shared responsibility between radiologists, clinicians, and patients alike. Radiologists must stay vigilant in maintaining the safety in diagnostic imaging techniques by following the standards set by the American College of Radiology (ACR) and by following the ALARA principle (As Low As Reasonably Achievable) when balancing CT dose and image quality. Clinicians should take time to refer patients to ACR accredited imaging facilities, where stringent standards must be met, and work with radiologists to choose the most appropriate imaging modality that may best serve to answer the clinical question posed. This collaboration can be made either through direct consultation with a radiologist or through guidelines established by the ACR (ACR Appropriateness Criteria, see below). Patients must also play an active role in their own healthcare decision-making. Specifically, this can be accomplished by keeping an individual radiation dose log, by asking their physicians questions, especially regarding the necessity of an exam, and inquiring about possible alternatives, including exams performed without ionizing radiation such as ultrasound and MRI.

With recent advances in CT technology and imaging protocols, which serve to minimize radiation dose based on a patient's age, size, and weight, there is no question that CT scans performed today are safer than in the past. New technological developments, especially in the field of electronic data transfer, may also soon enable physicians across specialties to share online access of a patient's medical record, including an imaging log and radiation dose history, which helps them to make more informed decisions and prevents unnecessary duplication of studies that contribute to needless increased exposure. Continued physician awareness and education, starting early within medical training programs, will also serve to play a vital role in the future of medical radiation exposure reduction.

Tools for Radiologists, Clinicians, and Patients

1. www.xrayrisk.com : This website features an excellent resource for the calculating the relative radiation risk associated with various radiologic examinations and procedures, as well as a tool for tracking an individual's radiation dose over time.
2. www.radiologyinfo.org : This website is geared towards educating patients, and contains a wealth of additional information regarding various radiologic exams and radiation safety profiles.
3. http://www.acr.org/secondarymainmenucategories/quality_safety/app_criteria.aspx : This is the American College of Radiology's website, which contains a search engine that radiologists and referring physicians alike may use to view the most appropriate imaging modalities (compiled by a panel of experts) for individual symptoms or clinical diagnoses.
4. www.imagewisely.org : New radiation awareness program developed by the American College of Radiology, the Radiological Society of North America, the American Association of Physicists in Medicine, and the American Society of Radiologic Technologists. Image Wisely's objective is to encourage practitioners to avoid unnecessary ionizing radiation scans and to use the lowest optimal radiation dose for necessary studies.
5. www.imagegently.org : Initiative by the Alliance for Radiation Safety in Pediatric Imaging with its stated goal to change practice by raising awareness of the opportunities to lower radiation dose in the imaging of children.

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