ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

Radiation Safety in Diagnostic Radiological Imaging: What Should We Know? A Radiologist's Perspective

Yogesh Kumar MD, Chief Resident, Kusum Hooda MD, Resident

Department of Radiology, Yale New Haven Health System at Bridgeport Hospital Bridgeport CT USA 06610

Manuscript Info

Manuscript History:

Received: 12 February 2015
Final Accepted: 22 March 2015
Published Online: April 2015

Key words:

Radiation Dose, Radiation Protection, Computed Tomography

Corresponding Author

Yogesh Kumar MD

Abstract

There has been rapid growth in medical uses of radiation in the past decade. Medical uses represent the largest source of exposure to the population. Most physicians have difficulty assessing the extent of potential risk. Increasing use of imaging modalities using ionizing radiation are known to result in an increased incidence of cancer in the exposed population. Preventing the inappropriate use of such imaging and by optimizing studies that are performed to obtain the best image quality with the lowest radiation dose can be used to minimize the radiation effects. Special efforts have been employed to decrease the radiation doses in pregnant patients and children who are at more risk to the harmful effects of radiation. Guidelines by various societies are very helpful in guiding the physicians in better patient care with reduced patient radiation doses.

INTRODUCTION

Use of ionizing radiation for diagnostic purposes in medicine started more than a century ago. Although in most of the imaging procedures, the benefits exceed the risks, there are others for which the benefit is not clear. It is the duty of the radiologist and referring physician to assess the potential benefit-risk ratio for various procedures. Recent development of multidetector row computed tomography and the increased utilization of imaging studies have improved the patient care by arriving at correct diagnosis quickly. However, this has also resulted in a significant increase in exposure to ionizing radiation (Amis 2010). To decrease the individual patient and population cumulative radiation doses, we need to have information of the magnitude of the radiation dose associated with the imaging procedures. Radiation exposure and doses in medicine can be quantified in a number of ways, which includes air kerma, entrance surface dose, dose-area product (DAP), dose- length product (DLP), and administered activity in case of nuclear medicine examinations (Amis 2010). Organ absorbed dose and effective dose are other effective parameters used. Effective dose can be used to enable comparison between radiation risks from procedures that utilize ionizing radiation. The purpose of this article is to present effective doses from various procedures, explain the radiation effects and discuss various methods to decrease the radiation dose while maintaining the patient care. Special situations like radiation doses and effects on pediatric patients and pregnant patients will also be discussed.

DISCUSSION:

As discussed earlier, there has been significant increase in the radiation doses to the patients in last decade due to rapid increase in imaging utilization for patient care. Ionizing radiations used in these procedures have been proved to cause carcinogenic and non-carcinogenic effects on the patients. One study on atomic bomb survivors in Japan has been shown to cause statistically significant increase in cancer at dose estimates in excess of 50 mSv (Pierce 2000). Many imaging studies including computed tomography and nuclear medicine studies have effective radiation doses in the range of 15-25 mSv. Since many patients will have multiple studies, it is not uncommon to exceed 50 mSv. Due to the harmful effects of radiations, referring physicians and radiologist should be aware of the effective doses of most commonly performed imaging procedures which have been described in Charts 1 and 2 (Mettler 2008).

Radiation effects can be broadly divided in to two categories, deterministic effects and stochastic effects. Deterministic effects have a threshold of dose and severity of the effect is dose-related. Stochastic effects have no dose threshold and severity of the effect is not dose related. Deterministic effects include loss of hair**,** erythema, desquamation, diarrhea, and leucocytopenia. A stochastic effect causes change in cells leading to cancer and genetic defects. (Yoshinaga 2004)

Due to adverse effects of radiation, referring physicians, radiologist and technicians should work as team to decrease the radiation dose to the patients. Two very important principles of radiation protection developed by the International Commission on Radiological Protection include justification and dose optimization.

Justification:

Weather the imaging procedure would do more good than harm to the individual patient should be discussed about. Therefore, all radiological examinations should be performed only when necessary to answer a medical question, help treat a disease, or guide a procedure. The patient medical history and clinical indication should be carefully considered before referring a patient for any imaging examination.

Dose Optimization:

Radiological examinations should use techniques that are adjusted to administer the lowest radiation dose, which yields an image quality adequate for diagnosis or intervention. The technique factors used should be chosen depending on the clinical indication, patient age and size, and anatomical area scanned. Important principles to decrease radiation dose in fluoroscopy includes using lowest frame rate needed for each body portion, using smallest electronic magnification, removal of antiscatter grids whenever possible in small body parts and pediatric patients, collimation to the area of interest and use of last image hold and fluoroscopy store (Mahesh 2001)**.** Strategies in Computed tomography include using the lowest possible mA and Kvp based on the patient size and body part scanned, using automated tube current modulation and only scanning the medically necessary body part (Cynthia 2009).

Health Personal- Specific dose reduction strategies

Referring Physicians

Although some referring clinicians are very knowledgeable regarding radiation safety issues, others do not routinely consider this factor when ordering imaging examinations due to little or no training in dealing with radiation issues. Sometimes studies are ordered by supporting staff, which in turn reflects the behavior of the supervising physician. Long-term solution to this problem lays in education the medical students during radiology clerkships. Although non-radiology residents address patient safety issues very effectively, they generally lack the awareness specific to radiation safety. Radiation exposure issues associated with diagnostic imaging should be reinforced for non-radiology residents during their training years.

In short term, more interaction between radiologist and referring physician, and following the American College of Radiology appropriateness criteria will help in ordering appropriate studies to minimize radiation dose to the patients.

Radiologist:

Radiologist has the largest role to play in reducing the radiation dose to the patients. To play the role effectively, specially in the daily application of radiation safety principles, a standardized approach to physics education at the resident level is necessary. Radiologist should work closely with the referring physician to determine the best imaging study to give the required information while delivering minimum radiation to the patient. Radiologist should also guide the technologist to develop examination protocols and use other techniques to decrease the radiation dose.

Technologist

As a radiologic technologist is usually the first, and may be the only, health care professional to interact with a patient presenting for a radiologic examination, technologists need to be familiar with the technical aspects and the associated radiation dose and risk. They should check if patient has undergone multiple prior similar imaging studies and should discuss with the radiologist. They are also responsible for produce high quality images with the lowest possible patient doses. Radiologic technologists should understand and use well-established protocols in CT, nuclear medicine and other radiologic examinations. They should be aware of lead apron shielding techniques of the highly radiation sensitive portions of the body specifically in pregnant and pediatric patients.

Patient and examination-specific dose reduction strategies:

Pregnant patients- Due to the concern of radiation risk to the embryo/fetus, imaging the pregnant patient presents a unique challenge to the radiologist. Prenatal death, intrauterine growth restriction, small head size, severe mental retardation, reduced intelligence quotient, organ malformation, and childhood cancer are the potential effects of radiation. The probability of any effects depends on the radiation dose to the conceptus. To minimize radiation exposure to the fetus, it is very important to determine if an alternative non-radiation based imaging modality can be used to obtain the necessary diagnostic information. For non-emergent conditions, radiologists and physicians must also decide if CT scanning can be postponed until after the delivery. In a pregnant patient with suspected acute appendicitis, Magnetic resonance imaging (MRI) should be considered due to lack of ionizing radiation. Every effort should be made to avoid directly irradiating the pelvis to minimize dose to fetus. However, for scanning body regions outside the abdomen and pelvis, such as head and cervical spine CT for trauma, chest CT for suspected pulmonary embolism, the dose to the fetus is very low (< 0.1 mGy). This is because the scattered radiation levels decreases quickly away from the scan volume. However, of the patient's pregnancy status is unknown at the time of CT imaging, even for a routine dose-level, bi- phase CT exam of the abdomen and pelvis, the probability of birthing a healthy baby decreases by only 0.5% and thus do not necessitate medical intervention.(McCollough 2007)

Pediatric patients—Because pediatric patients have a longer life expectancy and their organs are more sensitive to radiation damage, the risk of cancer in children due to radiation exposure is about two to three times higher than adult. The risk of cancer induction for newborns is essentially the same as in the last trimester of pregnancy.

The best way to reduce the radiation dose to pediatric patients is to avoid unnecessary CT examinations and to look for alternative imaging modalities with less or no radiation exposure. Specific designed pediatric protocols for children must be used. These protocols usually include tube current modulation using automatic and manual technique using weight or size-based chart that can determine the appropriate kV and/or mAs for each patient. Techniques to reduce radiation dose in pediatric fluoroscopy has been described previously in the article. Due to small size of pediatric patients, there is less attenuation of x-ray beams and the noise level does not increase significantly with the decrease of kV for the same radiation dose. Therefore, a lower Kvp can be used to improve the contrast enhancement without increasing the noise significantly than in adult patients (Hernanz-Schulman 2011).

Cardiac CT-Constructing low dose cardiac CT imaging protocols while providing the best possible information for an accurate diagnosis should minimize the radiation exposure to the patient. Strategies include reducing tube voltage and current, using automated tube current modulation, prospective gating instead of retrospective gating and by limiting the field of view. Using the techniques outlined above, dose reductions upto 70-90% can be achieved when compared to earlier acquisition strategies for cardiac CT.(Mathew 2009)

Chart 1:

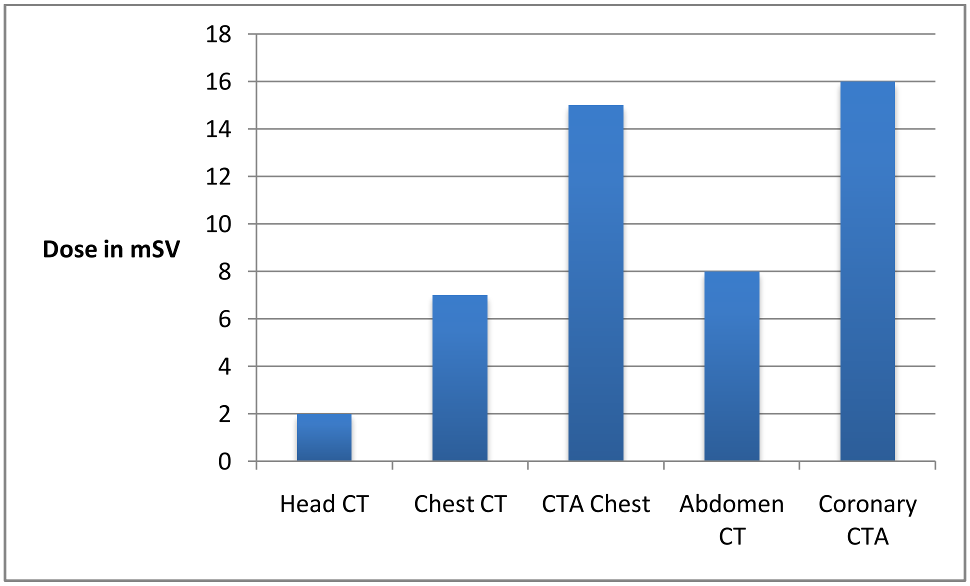
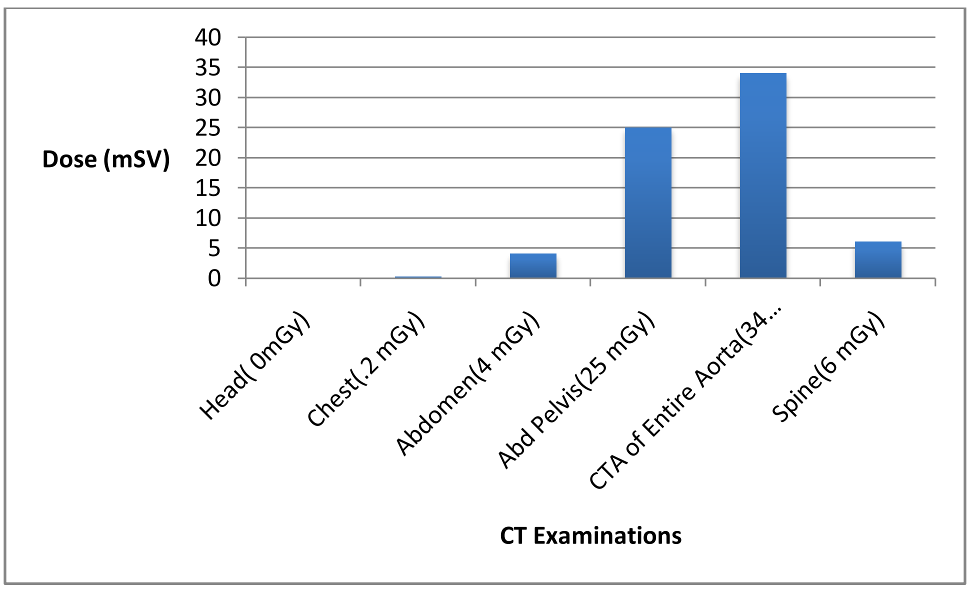


Chart 2:



Legends:

Chart 1: Average Adult Effective Radiation Doses in Various CT Examinations

Chart 2: Estimated Fetal/Embryo Doses from Single CT Examinations

CONCLUSIONS:

Although benefits of diagnostic imaging are immense, the rapid growth of diagnostic imaging studies over the past decade may result in an increased incidence of radiation-related cancer in the future. Referring physicians should be aware of these adverse effects to make an informed decision about ordering an imaging study. Clinician, radiologist and radiology technologist should work as a team to reduce the ionizing radiation doses to the patients. Special attention should be paid to pregnant and pediatric patients who are more sensitive to the radiation effects.

REFERENCES:

1. Amis ES Jr, Butler PF; White paper on radiation dose in medicine: three years later. J Am Coll Radiol. 2010 Nov;7(11):865-70.
2. Cynthia H. McCollough, PhD,a Andrew N. Primak, PhD,b Natalie Braun,c James Kofler, PhD,d Lifeng Yu, PhD,d and Jodie Christner, PhDc Strategies for Reducing Radiation Dose in CT Radiol Clin North Am. 2009 Jan; 47(1): 27–40.
3. Hernanz-Schulman M1, Goske MJ, Bercha IH, Strauss KJ. Pause and pulse: ten steps that help manage radiation dose during pediatric fluoroscopy AJR Am J Roentgenol. 2011 Aug; 197(2): 475-81
4. Mahesh M Fluoroscopy: Patient radiation exposure issues Radiographics. 2001 Jul-Aug; 21(4): 1033-45.
5. Matthew J. Budoff Maximizing dose reductions with cardiac CT Int J Cardiovasc Imaging (2009) 25:279–287
6. McCollough CH1, Schueler BA, Atwell TD, Braun NN, Regner DM, Brown DL, LeRoy AJ. Radiation exposure and pregnancy: when should we be concerned? Radiographics. 2007 Jul-Aug; 27(4): 909-17; discussion 917-8.
7. Mettler FA Jr1, Huda W, Yoshizumi TT, Mahesh M. Effective doses in radiology and diagnostic nuclear medicine: a catalog. Radiology. 2008 Jul; 248(1): 254-63
8. Pierce DA, Preston DL. Radiation-induced cancer risks at low doses among atomic bomb survivors. Radiat Res 2000;154:178-86.
9. Yoshinaga S, Mabuchi K, Sigurdson AJ, Doody MM, Ron E. Cancer risks among radiologists and radiologic technologists: review of epidemiologic studies. Radiology. 2004 Nov;233(2):313-21.