

Computed tomography: Are we aware of radiation risks in computed tomography?

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Abstract. People are constantly exposed to varying radiation and almost all of this exposure is due to diagnostic procedures. Although radiation has been proven to have adverse biological effects on living organisms, radiological examinations have an indispensable role in the diagnosis.

Particularly, Computed Tomography (CT) is valuable imaging tool and plays an important role in the evaluation of many diseases.

Radiation doses from CT scans ought to be kept to the ALARA (as low as reasonably achievable) and it shouldn't be forget that procedures are important in patient safety during imaging in the diagnostic radiology departments. The purpose of this review article is to support that no radiation doses can be considered completely safe and all efforts must be made to reduce both the radiation dose and damage.

Key words: Computed Tomography, radiation, the ALARA

1. Introduction

People are constantly exposed to varying radiation and almost all of this exposure is due to medical radiation, largely from diagnostic procedures. Heat and light are types of radiation that people can feel or see, but there are other kinds of radiation that human senses cannot detect (1). X-rays are forms of radiant energy. Unlike light, X-rays can penetrate the body, which allows a radiologist to produce pictures of internal structures. The radiologist can view these on photographic film or on a TV or computer monitor (2). It has been recognized since early studies on X-rays and radioactive minerals that exposure to high levels of radiation can cause clinical damage to the tissues of the human body (3).

According to Turkish Atomic Energy Authority's archive, as of 2012; the number of using X-ray devices, sealed and unsealed radioactive sources and equipments which

include radioactive sources is 10100. 73 percent of the radiation sourced are used in medical sector while rest of them are used in industrial or other activities in Turkey (4).

The purpose of this review article is to support that no radiation doses can be considered as completely safe and all efforts must be made to reduce both the radiation dose and damage.

Ionizing radiation

Ionizing radiation is defined as high-energy radiation that is capable of producing ionization in the tissues through which it passes and can be absorbed (5). Such "ionizing" radiation has been put to many uses such as doctors use X-rays to diagnose disease or injury, factories use radiation to check welds in machine components and gamma rays are used to sterilize medical equipment for safe use etc. (1). Ionizing radiation found in X-rays or gamma rays is defined as radiation and it has sufficient energy to displace electrons from molecules. Free electrons, in turn, can damage human cells (6). X-rays are an integral component for image formation with CT, there is an obligatory radiation exposure during the CT examination. Ionizing radiation has been demonstrated to increase the risk of cancer in individuals exposed to high doses of radiation (5).

Over the last 100 years, ionizing radiation has been increasingly applied in medicine and it is

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now firmly established as an essential tool for diagnosis and therapy (7). Exposure to ionizing radiation arises from sources such as medical diagnostic and therapeutic procedures (8). Radiological examinations have an indispensable role in the diagnosis and treatment of disease, although radiation has been proven to have adverse biological effects on living organisms (9).

How Dangerous Are CT Scans?

Diagnostic procedures, in particular the widespread use of X-rays, are the most common application of radiation in medicine. Diagnostic radiology uses range of X-ray techniques, such as radiography, fluoroscopy, computed tomography, will continue to provide tremendous benefits to modern healthcare and the benefit derived by the patient will far outweigh the small risk (7,10). Medical radiation has brought significant benefits to society. The risk of adverse effects, including cancer, from diagnostic radiology procedures is small, but the use of medical radiation, especially CT, are steadily rising (11).

If CT is compared with plain-film radiography, CT involves much higher doses of radiation, resulting in a marked increase in radiation exposure in the population (12). From the inception of CT in the 1970s, the use of CT has increased rapidly in all developed countries (12,13).

CT is a valuable imaging tool (5). CT scan is a special X-ray that scans an area one layer (slice) at a time (14). It is therefore imperative to understand how we missed the problem of excessive radiation, so we can both remedy it and prevent unnecessary exposure with newer technologies such as computed radiography (15). Of particular importance is the fact that there is no penalty in image quality for increasing patient dose. Absorbed dose is the major determinant in assessing the risks from ionizing radiation (16).

The development of a system of radiological protection that is used as the basis for regulations and practices worldwide, the International Commission on Radiological Protection (ICRP) and ICRP also provides information essential to the implementation of the system. Over the years, dose coefficients have been published in various ICRP reports (17). The frequency of CT examinations is increasing worldwide and the variety of examinations are also increasing. CT examinations can involve relatively high doses to patients (18).

Dose reduction techniques need to be explored in accordance with the ALARA (as low as reasonably achievable) principle

(5,13,15,16,19,34). In addition to this principle economic and social factors must be taken into account (10). This concept is strongly endorsed by the Society for Pediatric Radiology, particularly in the use of procedures and modalities of higher radiation doses such as CT (19). The ALARA principle requires that patients should not be exposed to any radiation that is not required for producing an image of diagnostic quality (16). The ICRP, in its 1990 Recommendations, divided situations affecting radiation exposure of individuals into two broad categories: practices and intervention. The basic principles of radiation protection were applied to these categories in different ways. In the case of practices, the principles were applied to the addition of radiation risk caused by the introduction or modification of practices (20).

It has been documented that radiation dose to the patient can be reduced significantly through optimization actions (21). All dose reduction strategies are predicated on the assumption that the CT scanner's radiation dose levels and image quality fall within manufacturer specifications and other general quality criteria (22). For CT, dose reduction should be optimised by the adjustment of scan parameters. Some of these parameters are mA, kVp, and pitch (1-37) and these can change according to patient weight or age, region, scanned and study indication. Other strategies include restricting multiphase examination protocols, avoiding overlapping of scan regions, and only scanning the area in question (23). The patient dose is directly proportional to the selected mAs value and the scan length (16).

Effective dose, in a single quantity, characterises to the exposure of an individual to both internal and external radiation sources in a manner, that is independent of the individual's body-related parameters, such as sex, age (for adults), anatomy, physiology, race, and other factors (17). The effective dose reflects the non-uniform radiation absorption of partial body exposures relative to a whole body radiation dose and allows comparisons of risk among different CT examination protocols (24).

McCullough et al (25) showed that table about mechanisms for dose reduction at CT in their article. These mechanism are X-ray beam filtration, X-ray beam collimation, X-ray tube current modulation and adaptation for patient body habitus (automatic exposure control), peak kilovoltage optimization, improved detection system efficiency, noise reduction algorithms.

The main reason for this higher dose contribution is, however, not due to an increase

of the dose from a single CT examination, but rather from an increase in the number of examinations and a widening spectrum of CT applications in general (26). Each CT exam must be appropriate for the individual patient. Justification is a shared responsibility between requesting clinicians and radiologists (22).

Is It True That CT Scans May Increase My Risk of Cancer?

CT is valuable imaging tool and plays an important role in the evaluation of many diseases. It has been recognized since early studies on X-rays and radioactive minerals that exposure to high levels of radiation can cause clinical damage to the tissues of the human body (27). CT scans can be performed on every region of the body for a variety of reasons (e.g. diagnostic, treatment planning, interventional, or screening). Most CT scans are performed as outpatient procedures (28).

The widespread use of CT represents probably the single most important advance in diagnostic radiology (12). The number of diagnostic and interventional medical procedures using ionising radiations is rising steadily, and procedures resulting in higher patient and staff doses are being performed more frequently (29).

Several studies (9,30-34,38,39) can be given about radiation in diagnostic radiology.

Gümüş et al (9) suggested in their study that the knowledge level of Turkish pediatric surgeons were inadequate on radiation exposure of patients during diagnostic imaging. They concluded this result: patients and their families should be informed on the lifetime cancer risks of ionizing radiation.

Larson et al (30) found a conspicuous lack of clear and concise information regarding CT-related radiation risk that is conveniently available to clinicians, patients, or even radiologists in their study.

Brenner et al (31) showed that the combination of higher radiation doses to children for a given CT examination and more importantly, the much larger lifetime risks per unit dose of radiation that apply to children, result in lifetime cancer mortality attributable to the radiation exposure from CT that is significantly higher in children than in adults. And they also showed that the larger doses and increased lifetime radiation risks in children produce a sharp increase, relative to adults, in estimated risk from CT.

Shiralkar et al (32) asked a convenience sample of 130 doctors at all different grades from two separate hospitals. They showed that in a convenience sample of doctors few had any

knowledge about the level of radiation that their patients were exposed to during radiological investigations.

Mathews et al (33) showed that CT scans during childhood and adolescence were followed by an increase in cancer incidence for all cancers combined and for many individual types of cancer in their study. They couldn't, however, necessarily assume that all the excess cancers seen during the current period of follow-up were caused by CT scans, because scanning decisions are based on medical indications and are not allocated at random.

Zhu et al (34) have showed that it is feasible to follow the ALARA principle and to optimize the radiation protection for patients during chest CT by reducing the radiation dose, thereby lowering the patient's risk of radiation exposure while ensuring an adequate image quality.

Since the number of CT examinations increase rapidly (5,31), CT radiation dose reduction continues to be placed on by the medical community and by the press. Several points must be considered regarding CT radiation dose. First, there is an argument that radiation exposure in medical imaging has a significant impact on cancer risk related to radiation exposure (35).

The superiority of CT scanning over projection imaging is based on its ability to eliminate organ or structural superimposition that usually occurs in the latter modality. Despite these benefits, CT as a digital modality has also the potential of producing diagnostic quality images with almost unlimited radiation dose since the detectors are linear over long ranges (36).

The international trend of increasing population exposure to medical diagnostic sources of radiation raises concerns about exposure to radio-sensitive organs. Numerous efforts are underway to minimise patient exposure from CT while maximising their benefits (37).

To literature and İnal et al, there aren't published Turkish data on patient doses in general radiography with digital X-ray systems (38).

Miller et al found that the risk of breast cancer among Canadian women exposed to X-ray fluoroscopic examinations for tuberculosis (39).

2. Conclusion

Patients are different in all culture, so dosage adjustment will vary according to the patient. To our opinion low-dose imaging programs must be increased and all health staff (radiologists, technologists, physicists etc.) should be encouraged to participate. Especially in Turkey

patients dosage adjustments and optimized protocols must be taught in this dose reduction program. Radiation doses from CT scans ought to be kept to the ALARA and it shouldn't be forget that procedures are important in patient safety during imaging in the diagnostic radiology departments.

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