CT Scan: Is It Really Safe?

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It has often been said that there is no one more afraid of radiation than the radiologist. From Day 1 of residency training, radiologists-to-be are taught that excess radiation can cause cancer and a multitude of other medical conditions. After Hiroshima, Nagasaki and Chernobyl, history has shown that excess doses of radiation can cause cancer.

When x-rays were first discovered in 1895, no one knew how potentially dangerous it could be. Lessons were learned the hard way thru unexpected and unfavorable experiences. In 1896, one year after the discovery of x-rays was announced, 23 cases of radiodermatitis were reported in the world literature.[1] The first American radiation fatality occurred in 1904 when Mr. Clarence Dally, Thomas Edison's assistant, died of cancer.[1] Marie Curie, discoverer of radium, died from radiation exposure, most likely from leukemia.[2] In the 1920s and 1930s, patients who received injections of radium salts for the treatment of tuberculosis and ankylosing spondylitis developed bone tumors. In the 1950s, there were reports of thyroid cancer among children with *tinea capitis* who were being treated using x-ray epilation.[3] The use of x-rays were then regulated but not stopped because the benefits far outweighed the risks.

The Computed Tomography (CT) Scan machine was invented in 1972[4] and used commercially soon thereafter. Since then, there was an incredible leap in the practice of medicine. Head injuries and trauma cases became routinely evaluated using CT. In recent years, CT has become the standard in screening for paranasal sinus disease, lung disease and coronary artery disease. Computed Tomography has become accessible and affordable. CT scan procedures are covered by health insurance in most First World countries.

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Equally incredible are what modern CT Scan machines are currently capable of doing. There can be three-dimensional (3D) rendering of any part of the body, selective rendering of just the muscles or just the osseous structures, angiography and venography. There is almost nothing that the CT Scan cannot visualize.

There are, however, some facts that cannot be denied. First, the CT Scan uses ionizing radiation to create medically useful images. Second, more radiation is used in CT Scans than conventional x-ray procedures. Third, because more CT Scan machines have been made available, its use is now more widespread. In 1980, roughly 3 million CT scans were performed in the United States. In 2006, this number reached 62 million. In 2007, the number was estimated at 72 million CT scans.[5,6,7] Fourth, because more CT Scan procedures are requested, we either have more patients exposed to radiation or the same number of patients undergo more CT scan studies. Fifth, more radiation is used in the multi-slice CT scans that pepper today's medical landscape than the outdated conventional and spiral CT Scans.

All these facts and statistics raise very important questions. How much radiation does a patient receive with each CT Scan procedure? Should we be alarmed by the amount of radiation that a patient receives with each CT Scan procedure? Is the CT Scan really safe?

Unfortunately, it is not that easy to answer these questions. It is not ethical to do a randomized control study on the effect of radiation on humans by intentionally irradiating them without any expected benefits. We have to content ourselves with data on radiation doses obtained in previous studies.

Textbooks say that a patient gets a dose of 0.06 mSv of radiation when he undergoes a standard chest x-ray.[8] The mSv (milliSievert) is the SI unit for radiation absorbed dose. No such value can be measured for chest CT Scans because of the differences in protocols used by different hospitals. What also comes into play is the capability of the CT Scan machine of each hospital. Logically, the thinner the slices of a CT study, the more slices there will be for a fixed length of body part. In the December 2009 issue of the Archives of Internal Medicine, it was interesting to note that the radiation doses varied greatly within and across institutions. For the same type of CT Scan (i.e. chest or abdominal), the

doses varied widely among 4 institutions in California. The range of doses from 4 institutions for abdominopelvic CT Scans was from 6 to 90 mSv.[9]

Thus, alternatives have been proposed when comparing x-ray and CT Scan radiation doses. In the article by Richard Knox, Dr. Rebecca Smith-Bindman, a radiologist from UCSF, compares the radiation from a conventional x-ray procedure to that received during one transcontinental flight and that from a CT Scan to about 500 transcontinental flights.[10] In the public information website of the American College of Radiology and the Radiological Society of North America, www.RadiologyInfo.org, effective doses and comparative doses of CT Scans are provided. When a person undergoes a chest x-ray, it is like receiving the equivalent of 10 days' worth of natural background radiation. The usual CT scan of the chest will cause an effective radiation dose of 7 mSv or 2 years' worth of natural background radiation.[11] An Intravenous Pyelogram (IVP) will give one the equivalent of 1 year of natural background radiation while a CT scan of the pelvis will give one the equivalent of 3 years' natural background radiation.

Huda and Vance undertook a study[12] to quantify approximate radiation doses for pediatric and adult CT. They were constrained to using water phantoms and not actual patients. They found that effective doses for a head CT for adults is 0.1 mSv, much like a regular chest x-ray. However, they also found that the effective doses for head CTs of neonates was approximately FOUR times higher. The abdominal CT doses for both neonates and adults is approximately 3 mSv. The difference though is the size of the abdomens of neonates and adults. The radiation is more "spread out" in an adult than in a neonate. This is testament to the need for more standardization in the performance of CT Scans.

It is probably appropriate at this point to note that the National Council on Radiation Protection & Measurements (NCRP), an office created by the US Congress in 1964 to be THE go-to body for radiation protection and usage concerns, does not set radiation dose limits for a patient and limits discussion to occupational workers, pregnant women and the general population. That is, if the radiation received will help enhance the management of a patient who will undergo the radiologic procedure.[13]

We thus turn our attention to those people who are not technically patients, those who are not really sick but who undergo CT Scans anyway—patients who undergo screening CT Scans.

Clinical practice guidelines for adult sinusitis were published in the Journal of Otolaryngology-Head and Neck Surgery.[14] These guidelines expressly stated that routine diagnostic imaging should not be done for those patients who fit the clinical criteria for acute sinusitis. Also stated in these guidelines are the following: "**The clinician should obtain computed tomography (CT) of the paranasal sinuses in diagnosing or evaluating a patient with chronic rhinosinusitis or *recurrent* acute rhinosinusitis**. *Recommendation based on diagnostic and observational studies and a preponderance of benefit over harm*." Since this is for chronic or recurrent cases, it is understood that more than one CT Scan of the paranasal sinus area will be taken.

The same issue was brought up in the monitoring of patients with cystic fibrosis (CF). These patients used to have lower life expectancies and did not live past childhood. Lately, however, studies have shown that CT Scans are able to detect lung damage earlier, allowing for better management and consequently longer life expectancies.[15] De Jong states, "Further improvements in life expectancy are expected over the next three decades. Because the risk of radiation-associated cancers increases with increased longevity, the potential harm from routine CT scanning is likely to be amplified in the future for patients with CF."

The Japanese Respiratory Society, in its Clinical Practice Guidelines for the Diagnosis and Treatment of Chronic Obstructive Pulmonary Disease,[16] recommends high resolution CT Scan for the evaluation of emphysema although there is no mention of the recommended frequency in doing CT Scans.

It is also interesting to note that if one does a Google search of "CT scan screening", one website (www.fda.gov) does not recommend routine CT Scan screening for lung cancer and nine websites urge people to think about getting CT Scan screening for lung cancer and coronary disease. Subsequent pages mention CT colonoscopy for colon cancer screening. These websites are notably commercial sites.

The risk of overdoing the CT scans is real. New technology is being developed everyday that is making image resolution higher and higher. There is literally very little that the human body can hide from a CT Scan. But again the question is, so what if more CT Scans are done on a person? How will more CT Scans affect the body?

It is common knowledge that radiation can cause cancer. What is not common knowledge however, is how much radiation is needed to induce a cancer.

De Jong, Mayo et al[15] in their study of CT screening for cystic fibrosis concluded that when the median survival of CF patients was short, the cumulative risk of all cancer deaths (hematologic and solid cancers) was between 1% and 2% by age 40 for both sexes. When median survival of CF patients increased to 50, the cumulative mortality was approximately 13% in both men and women when annual CT scans were used from age 2 onwards. The risk decreased by approximately half (7%) when annual CT scan screening was discontinued by age 18. They admitted that there were limitations to their study so the estimations may have been high. The risk for cancer deaths is however, real. In their words "the risk of routine lifelong annual CT scanning in CF

is low but will increase as the general survival of CF patients improves."

David Brenner & Carl Elliston from Columbia University, in their study published in Radiology[17] concluded that "a 45 year old adult who plans to undergo annual full-body CT examinations up to age 75 would accrue an overall estimated lifetime attributable risk of cancer mortality of about 1.9%". Again, calculation and modeling were done. The doses and risks used were from previously published data and the conclusion was the same. Although the risk is small, it is real.

Chodick, et al projected that 9.5 lifetime deaths would be associated with 1 year of pediatric CT scanning, a number representing an excess of 0.29% over the total patients who are estimated to die from cancer in their lifetime.[18] They found that children below 3 had the highest excess risk and this risk went down steadily with age. The authors used the same methods that Brenner above had previously used in other publications. Again, the risk is small but not zero.

De Gonzales, et al[19] estimated that 29,000 future cancers could be related to the CT Scans performed in the US in 2007 alone, representing 0.04% of the 70 million CT scans performed that year. The largest contribution came from CT scans of the abdominopelvic area. One-third of the projected cancers were due to scans done to patients in the 35 to 54 year-old age group.

Online news such as Medscape and National Public Radio also carry news items regarding the increased cancer risk associated with CT Scans.

We can therefore conclude that the CT Scan is safe to use and has its place in the management of disease. With disease management, the use of radiation is still risk vs. benefit. Most of the time, the benefit greatly outweighs the risk. But we should not forget to monitor patient doses, a job that can be done by a medical physicist equipped with the appropriate measuring devices.

We can also conclude that there is a small but real risk that an excess number of CT Scans can cause cancer. However, since each person's intrinsic oncogenic potential is different, we cannot cite a specific number when talking of excess numbers of CT Scans.

This may sound strange coming from a radiologist. Theoretically, the more the merrier. But, the ultimate lesson here for doctors is to follow the principles of radiation protection. Request only the necessary studies for their patients (principle of optimization) and request these only when they are needed (principle of justification). Moreover, the number of exposures must be limited to the minimum amount necessary to get adequate information and NOT to produce a beautiful slide for presentation purposes. After all, the motto of every physician should be "First do no harm."

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