

Risk Of Cancer And Radiation Dose Received By Patients From Common Diagnostic Radiological Examinations

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ABSTRACT

Background: Although radiological diagnostic studies (RDS) are an important and acceptable part of medical practice, it is not without hazards. It is associated with increased risk of cancer. Unfortunately the typical and safe dose of each radiological examination is not known. Most of our knowledge of cancer risk comes from studies of survivors of those exposed to whole body radiation from atomic bomb in Hiroshima & Nagasaki, jobs associated with radiation exposure, Chernobyl survivors & patients treated with radiation therapy for cancer and other diseases.

Objectives To estimate radiation dose received by patients from diagnostic radiological examinations and lifetime attributable risk of cancer (LTARC).

Type of the study: A prospective study.

Methods A prospective study was conducted in Al-Kindi Teaching Hospital (KTH) during the period from 1st June to 31st august 2016. The study was performed on 910 adult patients. There were 595 males (65.38%) and 315 females (34.62%); mean age was 41.5 years (range 20-63). Different RDS were considered including chest-x ray (CXR), skull x-ray(SXR), x-ray of limbs and pelvis (LPXR) for orthopedic causes , computed tomography scan (CTS) and mammography (MG) .

Results CXR was performed for 260 (28.57%) patients which delivers 0.12 mSv. SXR was done for 160 (17.58%) patients which delivers 0.3 mSv. LPXR was performed for 220 (24.175%) which delivers 0.3-0.6 mSv. MG exposes 150 (16.48%) to 3 mSv. While CTS ,which delivers 6.2-16 mSv according to anatomic area being scanned, was done for 120(13.19%) patients.

Conclusion There is great abuse for using RDS from both patients and doctors, without realizing their danger and association with cancer development. It was proved that RDS expos patients to different kinds of tissues injury including cancer.

Key Words Ionizing Radiation, Cancer Risk, Radiological Diagnostic Studies, Radiation Dose

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There are many different types of radiation - from the light that comes from the sun to the heat that is constantly coming off our bodies. But when talking about radiation and cancer risk, it is often x-rays and gamma rays that people think about. X-rays and gamma rays can come from natural sources. But this type of radiation can also be man-made. X-rays and gamma rays are created in power plants for nuclear energy, and are also used in smaller amounts for medical imaging tests, cancer treatment, food irradiation, and airport security scanners. If ionizing radiation passes through a cell in the body, it can lead to mutations (changes) in the cell's DNA, the part of the cell that contains its genes (blueprints). Sometimes this causes the cell to die, but sometimes it can lead to cancer later on. The amount of damage caused in the cell is related to the dose of radiation it receives. The damage takes place in only a fraction of a second, but other changes such as the beginning of cancer may take years to develop⁽¹⁾. Medical uses of x-ray, whether diagnostic or therapeutic increases and becomes an integrating part of medical practice. For example total number of CTS examinations performed annually in the United States has risen from approximately 3 million in 1980 to nearly 70 million in 2007^(2,3). Integrating CTS into routine care has improved patient health care dramatically, and CTS is widely considered among the most important advances in medicine. However, CTS delivers much higher radiation doses than do conventional diagnostic x-rays. For example, a chest

CTS scans typically delivers more than 100 times the radiation dose of a routine frontal and lateral chest radiograph^(4,5). Exposure to ionizing radiation is of concern because evidence has linked exposure to low-level ionizing radiation at doses used in medical imaging to the development of cancer. Most of our knowledge of cancer risk comes from studies of survivors of those exposed to whole body radiation from atomic bomb in Hiroshima & Nagasaki, jobs associated with radiation exposure, Chernobyl survivors & patients treated with radiation therapy for cancer and other diseases⁽⁶⁾. Radiation doses associated with commonly used CT examinations resemble doses received by individuals in whom an increased risk of cancer was documented. For example, an increased risk of cancer has been identified among long-term survivors of the Hiroshima and Nagasaki atomic bombs, who received exposures of 10 to 100 millisieverts (mSv)⁽⁷⁻¹⁰⁾. A single CT scan can deliver an equivalent radiation exposure⁽¹¹⁾, and patients may receive multiple CT scans over time⁽¹²⁾. Large number of people exposed, coupled with the increasingly high exposure per examination, could translate into many cases of cancer resulting directly from the radiation exposure from CT. It is important to understand how much radiation medical imaging delivers, so this potential for harm can be balanced against the potential for benefit. This is particularly important because the threshold for using CT has declined, and CT is increasingly being used among healthy individuals, in whom the risk of potential

carcinogenesis from CT could outweigh its diagnostic value.

Our study aimed to estimate how much radiation exposure is associated with the different types of X-ray examinations performed most commonly in diagnosis.

Methods: A prospective study was conducted in Al-Kindi Teaching Hospital (KTH) during the period from 1st June to 31st august 2016. The study was performed on 910 adult patients. There were 595 males (65.38%) and 315 females (34.62%); mean age was 41.5 years (range 20-63). Data was collected from department of radiology in Al-Kindi Teaching Hospital. Data included type of diagnostic examination and dose exposure in mSv received by patient, gender and age of patient. These RDS included CXR, SXR, LPXR, CTS and MG. Patients were selected from both emergency room (ER) and cold cases since radiation dose didn't differ. All patients were adults (20-63 years). The different types of the RDS, the number of patients exposed and the radiation dose are shown in table1.

Table-1 No. of patients with type and dose of RDS.

| Number of patients | Type of the study | Dose of radiation per patient (mSv) |
|--------------------|-------------------|-------------------------------------|
| 260 | CXR | 0.12 |
| 160 | SXR | 0.3 |
| 220 | LPXR | 0.3-0.6 |
| 150 | MG | 3 |
| 120 | CTS | 6.2-16 |
| 910 (Total) | | |

The dose delivered to patients represents the average in mSv that is usually used in KTH department of radiology. These doses are similar to those used elsewhere. Sensitivity of different tissues to radiation is shown in figure-1.

The doses received by patients were compared to levels of radiation that is injurious or lethal to human beings tissues. Figure 2 shows the effect of different doses of radiation in mSv.

Results: Males include 65.38% (595), while females form 34.62% (315). All patients were adults with mean age 41.5 years (range 20-63). CXR was performed for 260 (28.57%) patients which delivers 0.12 mSv. SXR was done for 160 (17.58%) patients which delivers 0.3 mSv. LPXR was performed for 220 (24.175%) which delivers 0.3-0.6 mSv. MG exposes 150 (16.48%) to 3 mSv. While CTS ,which delivers 6.2-16 mSv according to anatomic area being scanned, was done for 120(13.19%) patients.

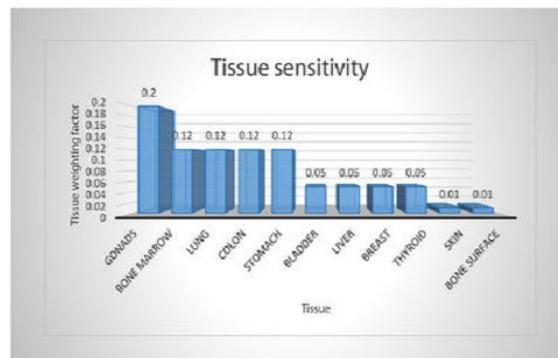


Figure-1 Tissues sensitivity to radiation (mSv)

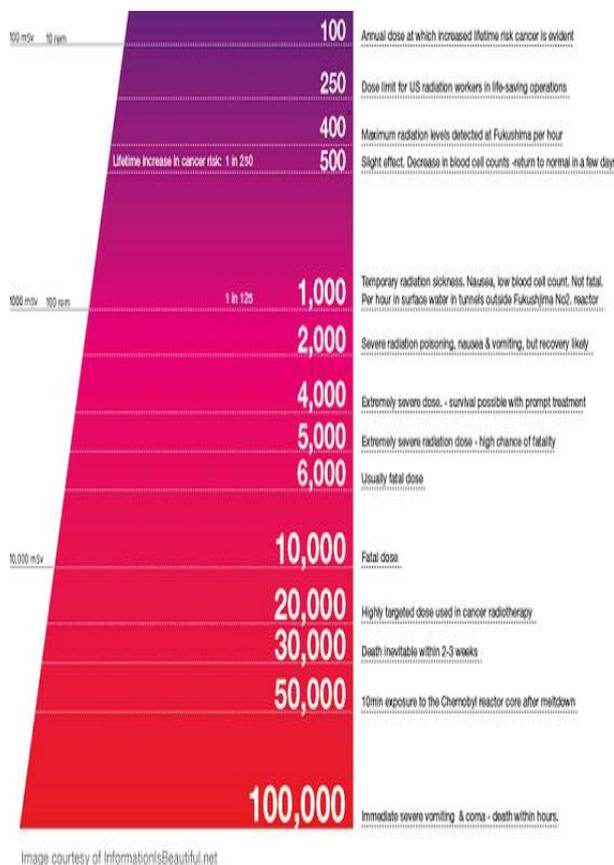


Figure-2 Effect of different doses of radiation (mSv)

The amount of radiation varies depending on the type of RDS. The usual dose for ordinary CXR is 0.12 mSv. For orthopedic (pelvis & bones) exposure the dose is 0.2-0.3 mSv. For SXR it is 0.3 mSv. MG examination dose is 3 mSv. The dose is much higher for CTS, which differs according to the area being scanned. It is higher for abdomen being 14-16 mSv while the lower CTS dose is

for chest & brain (9.6 & 6.2 respectively). The dose will double if a contrast media is used with CTS study. The highest dose is for coronary angiography which is 22 mSv. Increased risk of cancer after imaging tests that use x-rays often involve people who had multiple tests or high dose procedures. The number of patients received 0.12-0.3 mSv was 420 patients (46.17%). While those who received 0.3-0.6 mSv was 220 (24.17%). Patients received 3 mSv were 150 patient (16.48%). Those who received higher doses (6.2-16 mSv) were 120 patients (13.18%). The results are summarized in table 2.

Table-2 summary of patient's number versus radiation dose.

| | No. of patients | % of total | Radiation dose received (mSv) |
|-------|-----------------|------------|-------------------------------|
| | 420 | 46.17 | 0.12-0.3 |
| | 220 | 24.17 | 0.3-0.6 |
| | 150 | 16.48 | 3 |
| | 120 | 13.18 | 6.2-16 |
| TOTAL | 910 | 100.00 | |

The dose of CTS is even more, nearly doubled, when contrast is used with CTS, i.e. it will be as high as 32 mSv. This will increase the risk of radiation. The performance of RDS were not always indicated, i.e. some of the RDS done for non medical causes as shown in table 3. This means exposing some patients to radiation risk by performing a not-needed RDS.

Table-3 Different causes for doing RDS

| Type of RDS (Indication) | Patient No. | % of total |
|--------------------------|-------------|------------|
| CXR (Trauma) | 260 | 28.57 |
| (Done by JD) | 100 | 10.99 |
| (CP+Dy) | 35 | 3.85 |
| (CI) | 25 | 2.75 |
| (NI) | 50 | 5.49 |
| | 50 | 5.49 |
| SXR (Headache) | 160 | 17.58 |
| (Trauma) | 30 | 3.29 |
| (NDA) | 95 | 10.44 |
| | 35 | 3.85 |
| LPXR (RT) | 220 | 24.175 |
| (OT) | 120 | 13.187 |
| (JP) | 50 | 5.494 |
| | 50 | 5.494 |
| MG (age>50y+SM) | 150 | 16.48 |
| (FU) | 100 | 10.99 |
| | 50 | 5.49 |
| CTS (HT) | 120 | 13.19 |
| (AbBT) | 85 | 9.35 |
| (NI) | 20 | 2.19 |
| | 15 | 1.65 |
| Total | 910 | 99.99 |

Key for abbreviations: RDS radiological diagnostic study, JD junior doctor, CP ches pain, Dy dyspnea, CI chest infectio NI no indication, NDA no data available, RT recent trauma, OT old trauma, JP joint pain, SM suspicious mass, FU follow-up, HT head trauma, AbBT abdominal blunt trauma.

Discussion : According to Biologic Effects of Ionizing Radiation seventh series report (BEIR VII) a comprehensive review of available biological and biophysical data supports a "linear-no-threshold" (LNT) risk model—that the risk of cancer proceeds in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans. Very high doses can produce damaging effects in tissues that can be evident within days after exposure. Late effects such as cancer, which can occur after more modest doses including the low dose exposures that are the subject of this report, may take many years to develop ⁽¹³⁾.

This study shows that variable doses were delivered to patients. Unfortunately some patients are exposed to radiation with the fact that there was no real indication for these RDS.

The median effective dose (MED) of an abdomen and pelvis CTS (a common type of CTS examination performed) is often quoted as 8 to 10 mSv ⁽¹⁴⁻¹⁵⁾. While in our study it is 16 mSv, which 1.5-fold higher. When contrast is used the dose will be doubled to 32 mSv. This is 3-fold higher than the MED, and it will increase the radiation risk. The risks declined substantially with age and were lower for men, so radiation-associated cancer risks are of particular concern for younger, female patients. It is precisely because the risks of cancer are so high among younger patients that we chose to illustrate the risk of cancer when CTS is used in a 20-year-old female patient. Although it is generally assumed that very little CTS imaging occurs in children and young adults, approximately 5% of all CTS examinations are performed in children, 10% of all CT examinations are performed in those aged 20 to 30 years, and 5% of 20-year old patients undergo CTS imaging per year ⁽¹⁶⁾. Neither physicians nor patients are generally aware of the radiation associated with CT, its risk of carcinogenesis, or the importance of limiting exposure among younger patients. It is important to make both physicians and patients aware that this risk exists ^(17, 18). The causes for higher doses of radiation are: First that there is no standardization for RDS between examiners. Second there is no protocol for RDS regarding the indications and dose of radiation to be followed by both physicians who order the study and the radiologist who perform it Looking to tissue sensitivity in figure 1 we will realize the low doses of radiation to which tissues are affected. In figure 2 we notice that low doses can produce damage to tissues and for long term cancer.

This subject needs more evidence and long term follow up to estimate life time attributable risk of cancer. Multicentre and met- analysis studies are needed to standardize the lowest effective doses of radiation needed for different RDS that become an essential part of medical practice for diagnosis and treatment. These need a close cooperation of both sides of medical practice, patients and physicians.

Conclusions : All RDS become an important part of medical practice both diagnostic & therapeutic. But It

was proved that RDS expos patients to different kinds of tissues injury including cancer. Unfortunately there is a great abuse for using them from both patients and doctors, without realizing their danger and association with cancer development. Their damaging effects on tissues and association with cancer formation make them a 2-edges sword.

We recommend that:

- 1- There should be a protocol for ordering any RDS according to the indication for doing such studies.
- 2- Weighting dangers against benefits of a single study.
- 3- Studies that give high radiation exposures like CTS should be ordered by senior doctors.
- 4- Physician-radiologist cooperation is very important; avoiding repeating the study within short necessary unless absolutely indicated.

References

- 1- American cancer society , X-rays, Gamma Rays, and Cancer Risk. Online.
- 2- Amis ES Jr, Butler PF, Applegate KE, et al; American College of Radiology. American College of Radiology white paper on radiation dose in medicine. *J Am Coll Radiol.* 2007;4(5):247-284.
- 3 . IMV Medical Information Division. CT Census Database and Market Summary Report. Greenbelt, MD: IMV; 2008.
4. Linet MS, Kim KP, Rajaraman P. Children's exposure to diagnostic medical radiation and cancer risk: epidemiologic and dosimetric considerations. *Pediatr Radiol.* 2009;39(S1) (suppl 1):S4-S26.
5. Mettler FA Jr, Huda W, Yoshizumi TT, Mahesh M. Effective doses in radiology and diagnostic nuclear medicine: a catalog. *Radiology.* 2008;248(1):254-263.
- 6- Rebecca Smith-Bindman, MD; Jafi Lipson, MD; Ralph Marcus, BA; Kwang-Pyo Kim, PhD; Mahadevappa Mahesh, MS, PhD; Robert Gould, ScD; Amy Berrington de Gonza' lez, DPhil; Diana L. Miglioretti, PhD. Radiation Dose Associated With Common Computed Tomography Examinations and the Associated Lifetime Attributable Risk of Cancer, *ARCH INTERN MED* 2009 VOL169 (NO. 22), /28.
- 7- Pierce DA, Preston DL. Radiation-related cancer risks at low doses among atomic bomb survivors. *Radiat Res.* 2000;154(2):178-186.
- 8- Preston DL, Ron , Tokuoka S, et al. Solid cancer incidence in atomic bomb survivors: 1958-1998. *Radiat Res.* 2007;168(1):1-64.
- 9- . Preston DL, Pierce DA, Shimizu Y, Ron E, Mabuchi K. Dose response and temporal patterns of radiation-associated solid cancer risks. *Health Phys.* 2003;85(1):43-46.
10. Brenner DJ, Doll R, Goodhead DT, et al. Cancer risks attributable to low doses of ionizing radiation: assessing what we really know. *Proc Natl Acad Sci U S A.* 2003; 100(24):13761-13766.
- 11- Mettler FA Jr, Thomadsen BR, Bhargavan M, et al. Medical radiation exposure in the US in 2006: preliminary results. *Health Phys.* 2008;95(5):502-507.
- 12- Sodickson A, Baeyens PF, Andriole KP, et al. Recurrent CT, cumulative radiation exposure, and associated radiation-induced cancer risks from CT of adults. *Radiology.* 2009;251(1):175-184.
- 13- Beir VII: Health Risks from Exposure to Low Levels of Ionizing Radiation Committee to Assess the Health Risks from Exposure to Low Levels of Ionizing Radiation: Richard R. Monson (Chairman) et al, Harvard School of Public Health; 2002. www.nap.edu.
- 14- American Association of Physicists in Medicine. The Measurement, Reporting and Management of Radiation Dose in CT: Report of AAPM Task Group 23 of the Diagnostic Imaging Council CT Committee. College Park, MD: American Association of Physicists in Medicine; 2008. AAPM report 96.
- 15- US Food and Drug Administration. What are the radiation risks from CT? 2008. <http://www.fda.gov/cdrh/CT/risks.html>. Accessed October 7, 2009.
- 16- Smith-Bindman R, Miglioretti D, Larson E. Rising use of diagnostic medical imaging in an large integrated health plan. *Health Aff (Millwood).* 2008;26(6):1491-1502.
- 17- Griffey RT, Sodickson A. Cumulative radiation exposure and cancer risk estimates in emergency department patients undergoing repeat or multiple CT. *AJR Am J Roentgenol.* 2009;192(4):887-892.
- 18- McBride J, Paxton B, Warddrop R. Majority of ordering physicians lack knowledge of radiation exposure risks from CT. Study presented at: 109th Annual American Roentgen Ray Society Meeting; April 27, 20