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RADIATION RELATED RISK OF IMAGING : SYSTEMATIC REVIEW IN LITERATURE

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Abstract:
This review is aiming to discuss the Radiation related risk of imaging. The present review was conducted by searching in Medline, Embase, Web of Science, Science Direct, BMJ journal and Google Scholar for, researches, review articles and reports, published over the past years. Books published on Radiation related risk of imaging. If several studies had similar findings, we randomly selected one or two to avoid repetitive results. Based on findings and results this review found Radiation doses varied significantly between the different types of CT studies. During follow-up, 74 of 178 604 patients were diagnosed with leukemia and 135 of 176 587 patients were diagnosed with brain tumors. We noted a positive association between radiation dose from CT scans and leukemia. Effective radiation doses for whole-body CT and for CT of the chest, abdomen, and pelvis were calculated using Monte Carlo simulation studies.

Keywords: *Radiation, risk , imaging*

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INTRODUCTION:

Medical imaging is the technique and process of creating visual representations of the interior of a body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues (physiology). [1] Medical imaging seeks to reveal internal structures hidden by the skin and bones, as well as to diagnose and treat disease. Medical imaging also establishes a database of normal anatomy and physiology to make it possible to identify abnormalities. Although imaging of removed organs and tissues can be performed for medical reasons, such procedures are usually considered part of pathologyinstead of medical imaging. [2]

As a discipline and in its widest sense, it is part of biological imaging and incorporates radiology which uses the imaging technologies of X-ray radiography, magnetic resonance imaging, medical ultrasonography or ultrasound, endoscopy, elastography, tactile imaging, thermography, medical photography and nuclear medicine functional imaging techniques as positron emission tomography (PET) and Single-photon emission computed tomography (SPECT). [3]

Measurement and recording techniques which are not primarily designed to produce images, such as electroencephalography(EEG), magnetoencephalo graphy (MEG), electrocardiography (ECG), and others represent other technologies which produce data susceptible to representation as a parameter graph *vs.* time or maps which contain data about the measurement locations. In a limited comparison, these technologies can be considered as forms of medical imaging in another discipline. [4]

Up until 2010, 5 billion medical imaging studies had been conducted worldwide.[1] Radiation exposure from medical imaging in 2006 made up about 50% of total ionizing radiation exposure in the United States. [2]

Medical imaging is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body. In this restricted sense, medical imaging can be seen as the solution of mathematical inverse problems. This means that cause (the properties of living tissue) is inferred from effect (the observed signal). In the case of medical ultrasonography, the probe consists of ultrasonic pressure waves and echoes that go inside the tissue to show the internal structure. In the case of projectional radiography, the probe uses X-ray radiation, which is absorbed at different rates by different tissue types such as bone, muscle, and fat. [5]

METHODS:

The present review was conducted Jan 2019 in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) declaration standards for systematic reviews. We reviewed all the topics on Radiation related risk of imaging. To achieve this goal, we searched Medline, EMBASE, Web of Science, Science Direct, and Google Scholar for, researches, review articles and reports, published over the past 15 years. Books published on Radiation related risk of imaging. Our search was completed without language restrictions. Then we extracted data on study year, study design, and key outcome of Radiation related risk of imaging. The selected studies were summarized, and unreproducible studies were excluded. Selected data are shown in the Table 1.

Inclusion criteria

We included studies of consecutive patients' representative of the Radiation related risk of imaging population. The participants were adults who had undergone Radiation.

Exclusion criteria

We excluded examinations performed in association with a therapeutic procedure, such as CT-guided abscess drainage.

Data extraction and analysis

Information relating to each of the systematic review elements was extracted from the studies and collated in qualitative tables. Direct analysis of the studies of radiation related risk of imaging is done with extreme caution, as different sampling techniques can provide bias as an overview of the assemblage.

RESULTS:

A 15-Country collaborative cohort study was conducted to provide direct estimates of cancer risk following protracted low doses of ionizing radiation. Analyses included 407,391 nuclear industry workers monitored individually for external radiation and 5.2 million person-years of follow-up. A significant association was seen between radiation dose and all-cause mortality [excess relative risk (ERR) 0.42 per Sv, 90% CI 0.07, 0.79; 18,993 deaths]. This was mainly attributable to a dose-related increase in all cancer mortality (ERR/Sv 0.97, 90% CI 0.28, 1.77; 5233 deaths). Among 31 specific types of malignancies studied, a significant association was found for lung cancer (ERR/Sv 1.86, 90% CI 0.49, 3.63; 1457 deaths) and a borderline significant (P = 0.06) association for multiple myeloma (ERR/Sv

6.15, 90% CI <0, 20.6; 83 deaths) and ill-defined and secondary cancers (ERR/Sv 1.96, 90% CI −0.26, 5.90; 328 deaths). Stratification on duration of employment had a large effect on the ERR/Sv, reflecting a strong healthy worker survivor effect in these cohorts. This is the largest analytical epidemiological study of the effects of low-dose protracted exposures to ionizing radiation to date. Further studies will be important to better assess the role of tobacco and other occupational exposures in our risk estimates. [6]

The study conducted a retrospective cross-sectional study describing radiation dose associated with the 11 most common types of diagnostic CT studies performed on 1119 consecutive adult patients at 4 San Francisco Bay Area institutions in California between January 1 and May 30, 2008. We estimated lifetime attributable risks of cancer by study type from these measured doses. [7]

Radiation doses varied significantly between the different types of CT studies. The overall median effective doses ranged from 2 millisieverts (mSv) for a routine head CT scan to 31 mSv for a multiphase abdomen and pelvis CT scan. Within each type of CT study, effective dose varied significantly within and across institutions, with a mean 13-fold variation between the highest and lowest dose for each study type. The estimated number of CT scans that will lead to the development of a cancer varied widely depending on the specific type of CT examination and the patient's age and sex. An estimated 1 in 270 women who underwent CT coronary angiography at age 40 years will develop cancer from that CT scan (1 in 600 men), compared with an estimated 1 in 8100 women who had a routine head CT scan at the same age (1 in 11 080 men). For 20-year-old patients, the risks were approximately doubled, and for 60-year-old patients, they were approximately 50% lower. [7]

In retrospective cohort study, we included patients without previous cancer diagnoses who were first examined with CT in National Health Service (NHS) centres in England, Wales, or Scotland (Great Britain) between 1985 and 2002, when they were younger than 22 years of age. We obtained data for cancer incidence, mortality, and loss to follow-up from the NHS Central Registry from Jan 1, 1985, to Dec 31, 2008. We estimated absorbed brain and red bone marrow doses per CT scan in mGy and assessed excess incidence of leukemia and brain tumours cancer with Poisson relative risk models. To avoid inclusion of CT scans related to cancer diagnosis, follow-up for leukaemia began 2 years after the first CT and for brain tumors 5 years after the first CT. [8]

During follow-up, 74 of 178 604 patients were diagnosed with leukemia and 135 of 176 587 patients were diagnosed with brain tumors. We noted a positive association between radiation dose from CT scans and leukemia (excess relative risk [ERR] per mGy 0·036, 95% CI 0·005–0·120; p=0·0097) and brain tumors (0·023, 0·010–0·049; p<0·0001). Compared with patients who received a dose of less than 5 mGy, the relative risk of leukaemia for patients who received a cumulative dose of at least 30 mGy (mean dose 51·13 mGy) was 3·18 (95% CI 1·46–6·94) and the relative risk of brain cancer for patients who received a cumulative dose of 50–74 mGy (mean dose 60·42 mGy) was 2·82 (1·33–6·03). [8]

Another study identified 952,420 nonelderly adults (between 18 and 64 years of age) in five health care markets across the United States between January 1, 2005, and December 31, 2007. Utilization data were used to estimate cumulative effective doses of radiation from imaging procedures and to calculate population-based rates of exposure, with annual effective doses defined as low (≤3 mSv), moderate (>3 to 20 mSv), high (>20 to 50 mSv), or very high (>50 mSv). [9]

During the study period, 655,613 enrollees (68.8%) underwent at least one imaging procedure associated with radiation exposure. The mean (±SD) cumulative effective dose from imaging procedures was 2.4±6.0 mSv per enrollee per year; however, a wide distribution was noted, with a median effective dose of 0.1 mSv per enrollee per year (interquartile range, 0.0 to 1.7). Overall, moderate effective doses of radiation were incurred in 193.8 enrollees per 1000 per year, whereas high and very high doses were incurred in 18.6 and 1.9 enrollees per 1000 per year, respectively. In general, cumulative effective doses of radiation from imaging procedures increased with advancing age and were higher in women than in men. Computed tomographic and nuclear imaging accounted for 75.4% of the cumulative effective dose, with 81.8% of the total administered in outpatient settings. [9]

Effective radiation doses for whole-body CT and for CT of the chest, abdomen, and pelvis were calculated using Monte Carlo simulation studies. The effective dose of the PET scan was estimated by multiplying fludeoxyglucose F18 radioactivity with dose coefficients. Lifetime attributable risks of cancer were calculated using the approach described in the Biological Effects of Ionizing Radiation VII report.

For a 50-year-old patient, an annual CT of the chest, abdomen, and pelvis for 10 years carries an estimated lifetime attributable risk of cancer of 0.9% for male patients and 1.3% for female patients, whereas an annual PET/CT each year for 10 years carries an estimated lifetime attributable risk of cancer of 1.6% for male patients and 1.9% for female patients. Lifetime risk was found to be higher in younger, female patients. The lifetime attributable risk of cancer was estimated to be as high as 7.9% for a 20-year-old female patient receiving a PET/CT scan every 6 months for 10 years. [10]

Table (1) Results from Sequencing Studies.

Authors	Design	Population	Main Results
Cardis et al (2007)[6]	A15-Country collaborative cohort study	407,391 nuclear industry workers monitored individually for external radiation and 5.2 million person-years of follow-up.	A significant association was seen between radiation dose and all-cause mortality [excess relative risk (ERR) 0.42 per Sv, 90% CI 0.07, 0.79; 18,993 deaths]. This was mainly attributable to a dose-related increase in all cancer mortality (ERR/Sv 0.97, 90% CI 0.28, 1.77; 5233 deaths). Among 31 specific types of malignancies studied, a significant association was found for lung cancer (ERR/Sv 1.86, 90% CI 0.49, 3.63; 1457 deaths) and a borderline significant (P = 0.06) association for multiple myeloma (ERR/Sv 6.15, 90% CI <0, 20.6; 83 deaths) and ill-defined and secondary cancers (ERR/Sv 1.96, 90% CI −0.26, 5.90; 328 deaths). Stratification on duration of employment had a large effect on the ERR/Sv, reflecting a strong healthy worker survivor effect in these cohorts.
Bindman etal (2009)[7]	cross-sectional study	11 most common types of diagnostic CT studies performed on 1119 consecutive adult patients at 4 San Francisco	Radiation doses varied significantly between the different types of CT studies. The overall median effective doses ranged from 2 millisieverts (mSv) for a routine head CT scan to 31 mSv for a multiphase abdomen and pelvis CT scan. Within each type of CT study, effective dose varied significantly within and across institutions, with a mean 13-fold variation between the highest and lowest dose for each study type. The estimated number of CT scans that will lead to the development of a cancer varied widely depending on the specific type of CT examination and the patient's age and sex. An estimated 1 in 270 women who underwent CT coronary angiography at age 40 years will develop cancer from that CT scan (1 in 600 men), compared with an estimated 1 in 8100 women who had a routine head CT scan at the same age (1 in 11 080 men). For 20-year-old patients, the risks were approximately doubled, and for 60-year-old patients, they were approximately 50% lower.

Pearce et al (2012)[8]	retrospective cohort study,	follow-up, 178 604 patients	During follow-up, 74 of 178 604 patients were diagnosed with leukaemia and 135 of 176 587 patients were diagnosed with brain tumours. We noted a positive association between radiation dose from CT scans and leukaemia (excess relative risk [ERR] per mGy 0·036, 95% CI 0·005–0·120; p=0·0097) and brain tumours (0·023, 0·010–0·049; p<0·0001). Compared with patients who received a dose of less than 5 mGy, the relative risk of leukaemia for patients who received a cumulative dose of at least 30 mGy (mean dose 51·13 mGy) was 3·18 (95% CI 1·46–6·94) and the relative risk of brain cancer for patients who received a cumulative dose of 50–74 mGy (mean dose 60·42 mGy) was 2·82 (1·33–6·03).
Reza etal (2009)[9]	Utilization data were used to estimate cumulative effective doses of radiation from imaging procedures and to calculate population-based rates of exposure	952,420 nonelderly adults (between 18 and 64 years of age)	During the study period, 655,613 enrollees (68.8%) underwent at least one imaging procedure associated with radiation exposure. The mean (±SD) cumulative effective dose from imaging procedures was 2.4±6.0 mSv per enrollee per year; however, a wide distribution was noted, with a median effective dose of 0.1 mSv per enrollee per year (interquartile range, 0.0 to 1.7). Overall, moderate effective doses of radiation were incurred in 193.8 enrollees per 1000 per year, whereas high and very high doses were incurred in 18.6 and 1.9 enrollees per 1000 per year, respectively. In general, cumulative effective doses of radiation from imaging procedures increased with advancing age and were higher in women than in men. Computed tomographic and nuclear imaging accounted for 75.4% of the cumulative effective dose, with 81.8% of the total administered in outpatient settings.
Wen JC, (2013)[10]	surveillance	Monte Carlo simulation studies	For a 50-year-old patient, an annual CT of the chest, abdomen, and pelvis for 10 years carries an estimated lifetime attributable risk of cancer of 0.9% for male patients and 1.3% for female patients, whereas an annual PET/CT each year for 10 years carries an estimated lifetime attributable risk of cancer of 1.6% for male patients and 1.9% for female patients. Lifetime risk was found to be higher in younger, female patients. The lifetime attributable risk of cancer was estimated to be as high as 7.9% for a 20-year-old female patient receiving a PET/CT scan every 6 months for 10 years.

DISCUSSION:

These data show that the use of computed tomography (CT) for diagnostic evaluation has increased dramatically over the past 2 decades. Even though CT is associated with substantially higher radiation exposure than conventional radiography, typical doses are not known. We sought to estimate the radiation dose associated with common CT studies in clinical practice and quantify the potential cancer risk associated with these examinations.

Use of CT scans in children to deliver cumulative doses of about 50 mGy might almost triple the risk of leukaemia and doses of about 60 mGy might triple the risk of brain cancer. Because these cancers are relatively rare, the cumulative absolute risks are small: in the 10 years after the first scan for patients younger than 10 years, one excess case of leukaemia and one excess case of brain tumour per 10 000 head CT scans is estimated to occur. Nevertheless, although clinical benefits should outweigh the small absolute risks, radiation doses from CT scans ought to be kept as low as possible and alternative procedures, which do not involve ionising radiation, should be considered if appropriate. [8]

In this study, we estimated cumulative effective doses of radiation from medical imaging procedures in nearly 1 million nonelderly adults across the United States. Approximately 70% of the study population underwent at least one such procedure during the 3-year study period, resulting in mean effective doses that almost doubled what would be expected from natural sources alone. Although most subjects received less than 3 mSv per year, effective doses of moderate, high, and very high intensity were observed in a sizable minority. Generalization of our findings to the nonelderly adult population of the United States suggests that these procedures lead to cumulative effective doses that exceed 20 mSv per year in approximately 4 million Americans. [9]

The National Council on Radiation Protection and Measurements recently reported that in the United States the per capita dose of radiation from medical imaging has increased by a factor of nearly six since the early 1980s [11]

Surveillance for metastasis from choroidal melanoma requires consideration of radiation-related LAR, surveillance without radiation, the relative risk of metastasis, and the potential benefits of early detection of metastasis. Our study demonstrates that the LAR of cancer varies by age and sex, with younger female patients being more radiosensitive. This is consistent with other studies [12] that report increased radio sensitivity of organs such as the breast or thyroid in younger patients. As expected based on the estimated radiation dose of each study, the LAR of cancer related to PET/CT protocols is higher than that related to CT of the chest, abdomen, and pelvis, with an alternating protocol carrying an intermediate LAR of cancer.

CONCLUSIONS:

In conclusion, we observed that radiation doses from commonly performed diagnostic CT examinations are higher and more variable than generally quoted, highlighting the need for greater standardization across institutions.

In addition, findings indicate that the current pattern of use of medical imaging in the United States among nonelderly patients is exposing many to substantial doses of ionizing radiation. Strategies for optimizing and ensuring appropriate use of these procedures in the general population should be developed.
Aggressive surveillance protocols incorporating CT scanning for detection of metastasis from primary choroidal or ciliary body melanoma appear to confer a significant substantial risk of a secondary malignant tumor in patients who do not succumb to metastatic melanoma within the first few posttreatment years.

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