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Cancer risks from diagnostic imaging modalities: A review

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Abstract
Radiology is used as the leading diagnostic tool for detection of various diseases and helps in significant treatment of the patients. The importunity for imaging is increasing due to improved imaging techniques and development of modern imaging modalities such as PET-CT and SPECT-CT. Radiographic examinations that involves ionizing radiation have extended in Emergency Care with development in radiological diagnostic techniques. The recent advances in medical imaging have provided extensive clinical estimation but have also increased radiation exposure doses to the patients. Healthcare services provide valuable information about diseases but repeat and overdose of radiation can increase the risk of cancer. X-ray and CT is the most preferred modality for emergency cases as it provides accurate diagnosis of patients. Ultrasonography (USG) is the safest modality used in diagnostic radiology for detecting pathologies in soft tissue/organs and also it is widely available Magnetic Resonance Imaging (MRI) also provides the cross- sectional images of organs in any plane of the body. MRI and ultrasonography are the choice of modality over X-Ray, CT and fluoroscopy as it provides higher sensitivity for diagnosis of patient's pathologies without any exposure to ionizing radiation to reduce risk of radiation induced cancer.

Keywords: cancer, CT, MRI, ultrasonography, AEC, mobile radiography, radiation

Introduction
The number of radiographic examinations has increased with the recent advances in imaging modalities. [1, 2] Radiology is used as the leading diagnostic tool for detection of various diseases and helps in significant treatment of the patients. [2] The importunity for imaging is increasing due to improved imaging techniques and development of advanced imaging modalities such as PET-CT and SPECT-CT. The evolution of PACS has also increased the demand of radiologic examinations as it provides the visualization of images very efficiently. [3]
However, even with remarkable development of imaging technology, there is lack of knowledge and appropriateness among radiology professionals about radiation doses related to radiologic examinations. [4] This has increased the lifelong emanation in patients, specifically Cancer risks due to these exposures. [5]
Radiological Procedures such as Barium Enema, CT procedures, fluoroscopic examination and interventional radiology contribute most of the radiation dose from diagnostic radiology. The radiation hazard to the individual patient is very small even from these high dose procedures in correspondence of benefit vs. risk in patient's favor. But the issue emerges when CT procedures are performed without proper justification, when cross-sectional images can be efficiently produced using other non- ionizing imaging modalities. [6] The understanding of radiation doses related to CT and Nuclear Medicine among all specialties was poor according to Nicholas Brown and Lee, but in spite of lack of knowledge, most physicians prioritize imaging scans over possible risks associated with the patients. [7]
According to ICRP, NCRP and several other scientific bodies, the biological effects due to the usage of ionizing radiation increases with the increased radiation dose. The risk of cancer increases with the use of diagnostic X-rays in patients particularly to the offspring of mothers exposed during pregnancy [8-11]. The recent advances in medical imaging have provided extensive clinical estimation but have also increased radiation exposure doses to the patients. [12]
The risk of Cancer is progressive with time and there is no threshold value of dose below which the carcinogenic risk is not present. [13, 14] Although Cancer occurring due to radiation exposure cannot be distinguished from Cancers that occur inevitably, so, cannot be considered as Cancer induced by radiation [15]. Even so the professional core of radiology practitioners is radiation protection. The lack of knowledge about radiation protection may depict as a minute risk to an individual patient, but the hazards appear notable at a population level [4].

Literature Review
Computed Tomography and Cancer Risks
The advances in Computed Tomographic techniques and development of Multidetector Computed Tomography (MDCT) have elevated the use of CT in detection of various diseases over last two decades [16-18]. However, the ionizing radiation used in CT have raised the risk of radiation induced Cancer. There may be elevated risk of

Leukemia, Thyroid Cancer and non-Hodgkin lymphoma (NHL) in adults with the Computed Tomographic examinations.

The Computed Tomography Procedures are often preferred in case of imaging children, when duration of exposure is less than 1 second. It provides accurate diagnosis along with cost effectiveness [19]. CT scan also plays key role in trauma imaging and provides early detection of diseases with prevention of unnecessary surgeries of the patients. [20]

According to an A-bomb Data, the estimated risk of lifetime leukemia from a CT head was about 1 in 1000 in case of pediatrics. [21])Therefore, apart from innumerable benefits, the CT examinations have to be balanced, to reduce the radiation effects related to cancer, especially in case of pediatrics who are more sensitive to radiation. [22]

Risk associated with Pediatrics Radiology

The use of radiological examinations is increasing rapidly for pediatric imaging. But the examination in which ionizing radiation are used, increase the risk of radiation induced cancer in later life. [23] The risk of radiation damage increases in case of pediatric patients due to their ongoing developmental stage. [24-26] Moreover, pediatric patients suffering from chronic diseases undergo radiographic examination at younger age and are susceptible to have frequent imaging examinations. The frequent rise with the use of CT scans for imaging pediatrics has also increased the risk 2000 times higher. [27]

Diana L. Miglioretti *et al*. reported that Brain CT scans are the most frequently used CT examinations in case of pediatrics that increases the risk of radiation induced Brain Cancer and Leukemia.

The increased use of ionizing radiation for abdomen and pelvic imaging also causes highest risk of cancer specifically in children. Most of these pelvic and abdomen radiographic scans are performed in cases of infection, appendicitis or pain which can also be diagnosed with ultrasonography that do not require ionizing radiation for imaging. [28]

Risk associated with Emergency Radiology

Radiology is an emerging tool for imaging of trauma patients. Healthcare services provide valuable information about diseases but repeat and overdose of radiation can increase the risk of cancer. X-ray and CT is the most preferred modality for emergency cases as it provides accurate diagnosis of patients. CT modality has improved the treatment plan and increased the diagnostic accuracy. It is used for imaging in trauma cases and other injuries but with very high radiation exposure dose. This high exposure doses can be minimized by using Automatic Exposure Control (AEC), which is a parameter that can reduce radiation exposure dose by 10-60% without affecting the image quality. However, usage of CT has increased the patient exposure. Fluoroscopy and CT works with ionizing radiation and it accounts 2% of all the cancers. [29, 30]

Mobile radiography also plays the key role in diagnosis of trauma cases but again ionizing radiation are used that increases risk of cancer. So, all the portable imaging examinations should be rationalized so that the benefit vs. risk ratio should be in patients favour. Justified portable X-Ray examinations will also reduce unnecessary radiation exposure to other emergency ward patients and healthcare professionals. [31]

Non-Ionizing Imaging Modalities: Reducing Risk of Cancer

Ultrasonography (USG) is the safest modality used in diagnostic radiology for detecting pathologies in soft tissue/organs and also it is widely available.

This modality is mostly preferred for pregnant women to visualize the condition of fetus and mother where the risk of radiation induced cancer can be avoided. USG also helps in diagnosis of breast pathologies with accuracy and it provides imaging guidance in breast biopsies for early detection of breast cancer. USG guided biopsies should be more preferable over X-ray and CT guided Biopsies to decrease the risk of radiation induced cancer. [32]

Magnetic Resonance Imaging is the gold standard modality that provides cross- sectional images of organs in any plane of the body without using ionizing radiation. It is used to assess soft tissue pathology, can differentiate between different types of lesion, whole body imaging in children and can be used for imaging follow –up cases. [33]

So, Ultrasonography and MRI are the most preferable modalities for imaging when risk of radiation effects are of primary concern and have to be minimized specifically in case of pediatrics, child bearing age females and pregnant women. [34]

Conclusion

Radiology is used as the leading diagnostic tool for detection of various diseases and helps in significant treatment of the patients. But the use of frequent radiographic examinations in diagnosis of various pathologies has led to increase radiation induced cancers. Repeat radiographic examinations can also be considered as one of the major reason for elevated risk of radiation induced cancer. These risks due to medical radiation exposures can be reduced by spreading awareness and knowledge of radiation protection among radiology practitioners. MRI and ultrasonography are the choice of modality over X-Ray, CT and fluoroscopy as it provides higher sensitivity for diagnosis of patients pathologies without any exposure to ionizing radiation.

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