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Article

A Comparative Study of Radiation Dose in CT and MRI Imaging Techniques

Ahmed Falih Al-ysari[1], Yasser Yassin Khudair[2], Mohammed Fouad Majeed[3]

1,2,3 Remote Sensing Unit, College of Science, University of Baghdad, Baghdad, Iraq
* Correspondence: ahmed.falih@sc.uobaghdad.edu.iq

Abstract: This study presents a comparative analysis of radiation dosage levels obtained through the utilisation of magnetic resonance imaging (MRI) and computed tomography (CT) techniques. Magnetic resonance imaging (MRI) scans do not utilise ionising radiation as they instead rely on magnetic fields and radio waves, in contrast to computed tomography (CT) scans that employ ionising radiation. The apprehensions over the potential hazards associated with radiation exposure during CT scans have raised challenges pertaining to patient care and professional well-being. The objective of this study is to conduct a comparative analysis and assessment of radiation dose levels associated with magnetic resonance imaging (MRI) examinations. Additionally, it seeks to investigate potential health hazards associated with radiation exposure from CT scans, analyse the factors that influence radiation dose in CT and MRI procedures, and evaluate the merits and drawbacks of MRI radiation dose.The objective of this inquiry is to comprehend the disparities in radiation exposure between CT and MRI. The study's findings will aid clinicians and patients in selecting imaging techniques by considering their benefits and potential risks in a more informed and efficient manner.

Keywords: MRI, CT, Radiation Dose, Imaging Technique

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1. Introduction

The term "radiation dose," also known as the "absorbed dose," is used to describe the quantity of energy that is absorbed by human tissue or, more precisely, the concentration of energy that is deposited in tissue after exposure to ionising radiation. The term "effective dose" is used to describe the millisievert (mSv) dose at which the intended outcome will be attained.

The utilisation of ionising radiation during computed tomography (CT) exams has raised persistent and escalating apprehension regarding the potential health hazards involved. [1] Magnetic resonance imaging (MRI) is a non-invasive modality utilised for visualising the human body's organs, tissues, bones, and various anatomical features. It employs robust magnetic fields and radio waves to generate images of the inside structures of the body.

MRI machines generate three-dimensional, cross-sectional images of the body without the requirement of radiation, unlike X-ray and CT scans. [2] Magnetic resonance imaging (MRI) is frequently employed by medical professionals to visualise anatomical structures that are challenging to observe using conventional imaging techniques, such as x-rays, computed tomography (CT) scans, or ultrasounds.

Magnetic resonance imaging (MRI) is a diagnostic modality that enables the identification of various diseases, encompassing cancer, cardiovascular and vascular disorders, stroke, as well as skeletal and muscular ailments [1, 2]. The expedited detection of initial tumours, facilitated by the enhanced quality of MRI scans, enables the preservation of patients' breasts [3].

The second component of a CT system consists of an X-ray source, a rotating table, an X-ray detector, and a data processing device that calculates, displays, and analyses measurement data. [3]. MRI provides comparable anatomical information about the neck to CT in most cases. However, its superiority over CT has not been conclusively proven in all applications The use of multiarray helical detector technology has greatly expanded the application of CT, especially in vascular imaging, and improvements in sequence and coil design have also significantly improved MRI over the past few years.

However, the distinguishing feature of MRI is its excellent soft tissue contrast and multiplanar imaging, which allows vessels, masses, and adjacent soft tissues to be easily distinguished MRI scans are especially helpful for patients in whom it is difficult to distinguish between the mass and surrounding soft tissue structures on CT scans. MRI typically allows him to identify these lesions at three orthogonal levels without changing the patient's position. While CT scans and their anatomical imaging have been primarily limited to transverse sections, volumetric scans using helical multi-row detector technology provide isotropic voxels and reformatted multiplanar CT significantly increases flexibility. MRI provides better exposure of the lower neck without the shoulder deterioration that occurs with CT scans. Dental restorations and highly calcified or ossified cartilage usually do not cause significant deterioration of MRI images. [4]

2. Materials and Methods

According to Arabi, H. etal (2018) by study abput Comparative study of algorithms for synthetic CT generation from MRI: consequences for MRI-guided radiation planning in the pelvic region. The same patient population and quantification metrics were used to evaluate a several of recently published synthetic CT generation algorithms in the literature, including machine learning, segmentation, and atlas methods.Were evaluated six of his MRI-guided synthetic CT generation algorithms.

The bladder, rectum, bones, and body boundaries from his MRI images were used to assess automatic organ contouring.DCNN demonstrated superior segmentation accuracy overall, With Dice index (DSC) values of 0.93 ± 0.17, 0.90 ± 0.04, and 0.93 ± 0.02, respectively, for the bladder, rectum, and bone. ALMedian demonstrated the least accuracy, with DSC values of 0.82 ± 0.20, 0.81 ± 0.08, and 0.88 ± 0.04, respectively. When it came to precisely obtaining synthetic CT readings within each organ, DCNN performed the best, with an average absolute error of 32.7 ± 7.9 HU within the periphery.

According to Edmund, J. M., & Nyholm, T. (2017). By A review of substitute CT generation for MRI-only radiation therapy. the review present a range of typical performance values for a several of important methods for producing sCT as compared to CT that have been documented in the literature in this review. based on the Scopus database's literature search, this search included 254 articles. The final 50 articles that satisfied all inclusion criteria were divided into groups based on the methodology, MRI sequence and contrast, number of subjects, and anatomical site examined. latter comprises the prostate, brain, torso, and phantom. Notable contributions were made to engineering and/or dosimetric performance measurements. Voxel-based methods have been used in the majority of his PET/MR research on the brains of five to ten patients. Usually, T1-weighted photos are utilised. The overall dosimetric agreement is between 2.5% and 0.3. While the success rate for the less stringent criteria is > 98%, the range of results for the strict 1% and 1 mm gamma criteria is 68-94%. For the brain, the mean absolute error (MAE) from 80 to 200 HU, while for the prostate, it is about 40 HU. Scores for bone dice vary from

0.5 to 0.95. The specificity and sensitivity of both measurements were reported to be >80, with an average number of correctly classified voxels of approximately 84%. This review shows that there are a number of promising approaches that appear to be clinically acceptable, even when using standard clinical MRI sequences. Further progress toward widespread clinical implementation may require a consistent frame of reference regarding measurement styles.

The purpose of the study is to compare and evaluate the radiation dose levels associated with computed tomography (CT) and magnetic resonance imaging (MRI) techniques. CT and MRI are commonly used for medical imaging, and each method has its own advantages and characteristics. However, both patients and healthcare providers have expressed concerns about the potential risks associated with radiation exposure from CT scans. To have a deeper comprehension of the potential advantages and disadvantages associated with each imaging modality, it is necessary to study and compare the radiation dose levels associated with the two methodologies.

The study aims to achieve specific objectives as follows:

1. Examine and compare the amounts of radiation exposure associated with magnetic resonance imaging (MRI) examinations.
2. The present study seeks to investigate the various factors that impact radiation exposure in the context of MRI and CT scans.

3. Results

Computed Tomography (CT):

It is a medical imaging technique that use X-ray technology for the purpose of diagnosing various illnesses and disorders. An advantage of this procedure is its painlessness, rapidity, and absence of adverse side effects.

The distinguishing factor of this device in emergency scenarios lies in its exceptional precision in promptly detecting internal haemorrhaging and injuries, hence ensuring the patient's survival. The X-ray function of this device generates radiographic images of the internal structures of the human body, which are utilised for the diagnosis of several medical conditions.

The ultimate visual representations can be transformed into three-dimensional images by the process of rebuilding them from CT scans in several frames, or alternatively, they can be placed onto a CD or DVD disc.Additional details on the X-ray image and CT scan images pertaining to the blood vessels, soft tissues, bones, and internal organs are requested.

Consequently, computed tomography (CT) scans facilitate the diagnosis of several medical conditions, such as cancer, cardiovascular disease, infectious diseases including tuberculosis (TB), and appendix disorders. Potential hazards associated with CT scans. Organ dosages in the tens of mGy range are frequently administered to patients having CT exams

This elucidates the reason behind the comparatively lower organ doses observed in CT scans, which fall below the threshold levels necessary to induce deterministic consequences like as skin burns, epilation, and ocular cataracts [5]. Following the occurrence of radioactive fallout on a global scale during atomic weapon air testing in the mid-1900s, scientists started to express significant concern regarding the genetic consequences of radiation.

Currently, the likelihood of developing cancer is considered to be higher than any hereditary risk. Both the societal ramifications of diagnostic radiography and the potential hazards associated with genetics are considered insignificant.

The main focus of concern pertains to the development of malignancies in patients exposed to doses of tens of mGy, encompassing both lethal and nonlethal outcomes.Therefore, our findings demonstrate that the optimal dosage for the chest, as determined by an X-ray, is 0.02 mSv. Similarly, the dosage for the head is approximately 30 times higher, the dosage for the belly is approximately 37 times larger, and the dosage for the CT scan is around 20 mSv, which is 1000 times more [6,7].Exercising prudence is essential when selecting between X-ray and CT scans due to the significant disparities in the radiation doses that each procedure imposes on the human body.

Quantifying the dose of CT radiation and the corresponding risk:

Various strategies can be employed to quantify the radiation exposure in CT scans. The dosage metrics that are commonly employed include the radiation output from scanners, effective dose, and organ dose. The current method for characterising the radiation output of the scanner is the volume CT dose index (CTDIvol), which utilises two standardised acrylic phantoms in a highly standardised manner [7].

The diameters of the head and body phantoms provided by CTDI are 16 cm and 32 cm, respectively, while their lengths are 14 cm. The unit of measurement that we employ is mGy. Currently, CTDIvol and related measurements like as dose length product and weighted CTDI (CTDIw) are commonly used for quality control testing, radiation output augmentation, and assessment of a specific scanning method.

Understanding that these dose metrics do not directly assess patient dosage, but rather serve as standardised measures of scanner output levels when evaluated in a standardised phantom, is of utmost importance. The accuracy of CTDI-based CT dosimetry is being called into doubt due to the introduction of cone-beam CT scanners and wider detector collimation [8,9].

A proposal was made to compute the radiation exposure to individual organs, including factors such as the exact dosage, age, sex, and features of the organs, for patients undergoing CT scans [10]. The term "whole-body equivalent" dose, also known as "effective dose," is commonly measured in millisieverts (mSv) and represents a dosage that would have a comparable health risk to that caused by partial body radiation [11, 12].

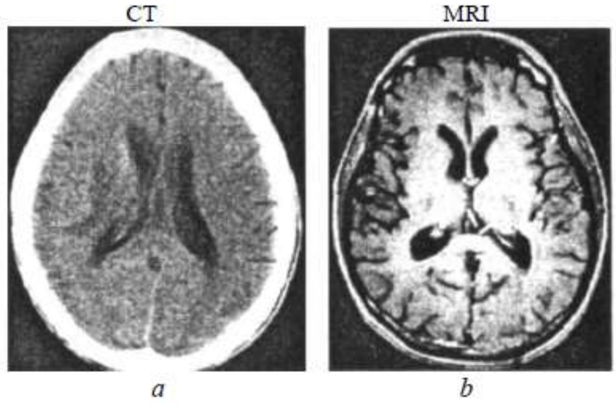
The effective dosage enables a fundamental evaluation of the radiation-induced risk connected with different types of examinations. [13]

Magnetic Resonance Imaging (MRI):

Low-intensity magnetic resonance imaging (MRI) is a non-invasive technique that is highly valuable for the examination and diagnosis of the human body, specifically for soft tissues, bones, and internal organs. In alternative terms, their molecular composition surpasses that of the entire human body.

In alternative terms, these entities predominantly consist of hydrogen atoms and serve as the fundamental building blocks of magnetic resonance technology. The magnetic resonance system exhibits significant magnetic fields, reaching amounts of radiation up to 1.5 Tesla.

Furthermore, radiation waves, such as harmful X-rays, can be used to excite human body cells that are easily visible and can be researched without the usage of radiation. Doctors prefer to emphasize that magnetic resonance imaging has the advantages of being three-dimensional, easily stored on a computer or disc, and reusable multiple times.



MRI can capture many pictures during surgery in order to evaluate the outcome of the procedure without causing any adverse effects [14].

Based on the aforementioned, Fig. 1 presents a summary of the benefits of MRI.

It is evident from the illustration Figure (1) that:

1. Determine the anatomical structure in detail.
2. Achieve a strong contrast of the soft tissue, which CT is unable to provide.
3. There is no radiation exposure like with CT because MRI uses radio waves and non-lethal magnetic fields.[15]
4. 4-MRIs are pricey, but with proper use, they last longer.
5. There is no radiological risk to the patient throughout the up to 20-minute magnetic resonance scan, which can be performed multiple times. As opposed to what occurs during tomography[16].

Concern over the health dangers linked with the use of ionising radiation in computed tomography (CT) scans is persistent and is becoming more so. This study aims to measure individuals directly. determine the dosages to each organ and evaluate the variations in these data under various CT scan circumstances [17].

MRI for Treatment Assessment:

The assessment of therapy response often involves measuring the alteration in tumour size, either in one dimension (RECIST and RECIST 1.1) or in two dimensions (WHO standards). The identification of biomarkers for early treatment response is widely recognised as extremely desired, as changes in size serve as a delayed indicator of medication effectiveness.

This assertion holds special validity within the contemporary era of immunotherapies, the integration of chemotherapy with radiation therapy, and the implementation of tailored chemotherapy.Magnetic resonance imaging (MRI) offers a distinctive chance to investigate various contrast processes with the aim of evaluating the initial response to treatment.

Functional magnetic resonance imaging (DWI) is a technology that allows for the observation of random or Brownian motion of protons within water molecules. The presence of numerous cells and intricate structures in cancer tissue hinders the flow of water molecules, leading to a reduced apparent diffusion coefficient (ADC) and a significant signal on diffusion-weighted imaging (DWI).

Tumour tissues will exhibit heightened necrosis and reduced overall cellularity as a result of therapy. This phenomenon will result in a reduction in the confinement of water molecules, hence generating a heightened ADC and a diminished DWI signal.

Multiple studies have demonstrated that variations in the diffusion signal and antigen-detection capacity (ADC) might serve as indicators for predicting the pathological reaction to different types of tumours, such as locally advanced rectal cancer and cervical malignancies that are undergoing combination neoadjuvant chemotherapy and radiation therapy (CRT).18Based on the % change in ADC and the post-CRT skewness of the ADC histogram, a recent study indicates that neoadjuvant CRT may yield favourable outcomes for individuals diagnosed with cervical cancer.[18]

Likewise, a limited-scale investigation on pancreatic cancer revealed an increase in the concentrations of ADC within the tumour subsequent to neoadjuvant chemoradiation.[19] Moreover, a correlation was observed between the levels of ADC after treatment and the degree of pathologic response.

Perfusion-weighted imaging (PWI) with DCE has also been employed to investigate the evaluation of therapeutic response following radiation therapy (RT). Nevertheless, the administration of an exogenous gadolinium contrast agent is necessary for this procedure. Further investigation is necessary to accurately assess the capabilities of several MRI endogenous contrasts, including as T1 and T2 relaxation rates, spectroscopy, and arterial spin labelling (ASL).[20]

Comparisons Between Medical Imaging Techniques CT and MRI

Three principles can be used to compare medical applications: spatial resolution, improved contrast, and image quality are the first two notions. The spatial extent of small items inside the image is referred to as the spatial resolution. The accuracy with which the signal is received is referred to as noise. The brightness or darkness difference in an image between an object of interest and its background is referred to as contrast The second idea is the system available, which is exemplified by the real-time information availability and the system cost. The impact of heating on the body and the effect of ionising radiation on the patient can be used to illustrate the third idea of safety. Table 1 provides a summary of the differences between the various MITs.[21]

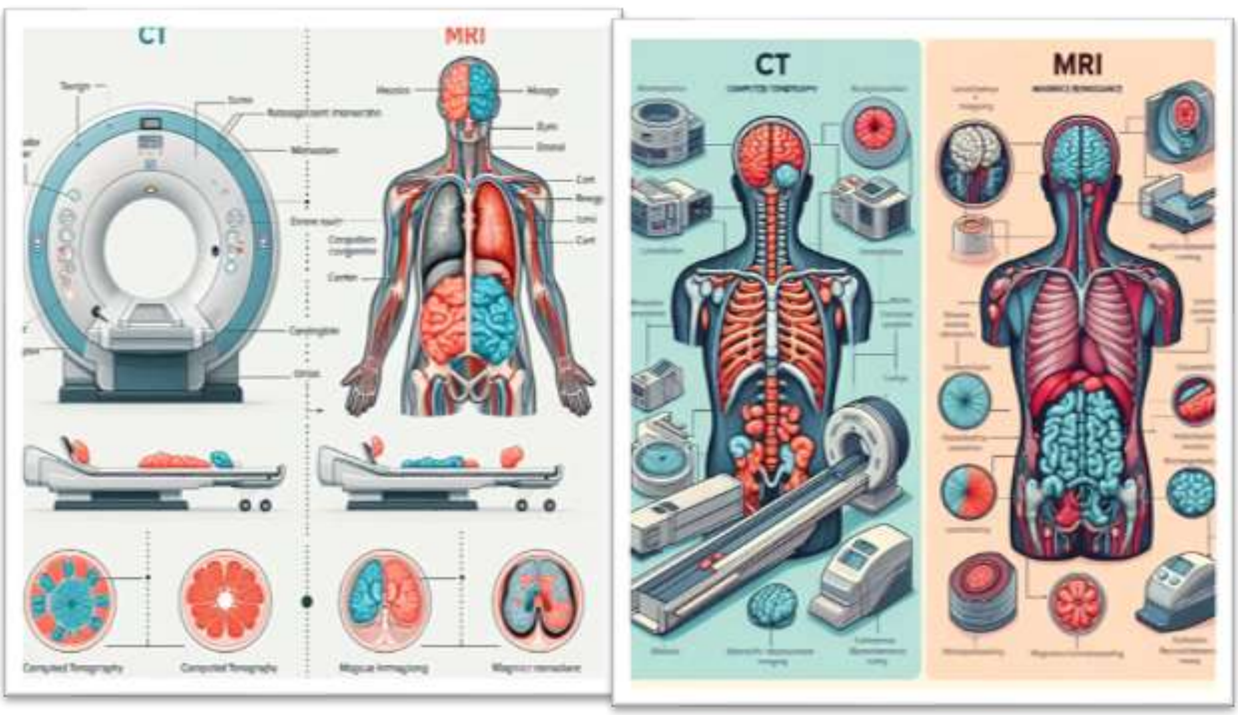


Figure **(2) showing the difference between CT and MRI**

	Image quality		System availability		safety	
Imaging Technique	Spatial resolution	Good contrast	cost	Real time information	Ionizing Radiation effect	Heating effect
CT	0.5 mm	Hard and soft tissue	high	NO	Yes	Low
MRI	0.5 mm	Hard and soft tissue	high	NO	NO	Medium

Table 1: Comparisons Between Medical Imaging Techniques CT and MRI

Feature	Computed tomography (CT)	magnetic resonance imaging (MRI)
Technology	Use of X-rays	The use of magnets and radio waves
Common use	Bones, internal bleeding, tumors	Soft tissues, brain, internal organs
Radiation	Yes	No
Speed	Faster and useful in emergencies	It takes longer
Cost	Usually less expensive	More expensive
Risk	Radiation exposure, especially for children and pregnant women	Claustrophobia, effects of magnets on metal implants

Table 2 : Comparison between computed tomography and magnetic resonance imaging

Results of the study were that CT scans use ionizing radiation and on the other side, MRI scans do not use ionizing radiation, but instead they use magnetic fields and radio waves. Thus, from this fundamental difference in the source of radiation, MRI is safer regarding radiation exposure. Concerns have been raised in the potential risks associated with CT scans, particularly in relation to occupational health and patient care. The study compared and analyzed the radiation doses associated with MRI examinations. They have found that the radiation dose in MRI scans is by far significantly less than that in CT scans. This is a significant observation since it points to the fact that using MRI would limit the dose of radiation exposure. Patients and healthcare providers, therefore, shall have more knowledge of what kind of imaging procedures might be done to them so that they can do proper decision-making of any given imaging procedure.

Quantification of CT radiation dose and the corresponding risk was discussed in the study. The overall scan volume CT dose index (CTDIvol), hence, volume CT dose index (CTDIvol), and average CTDIvol from a central read of individual scans were used to derive radiation exposure in CT scans. These metrics work as standardized measures of the scanner output levels, and thus, they offer valuable information to be used for quality control, radiation output enhancement, and evaluation of imaging techniques.

A patient might also be subjected to MRI since it's a non-invasive examination that does not contain ionizing radiation. Thus, patients with repeated imaging requirements can safely undergo MRI since it uses a lower dose of radiation. The improved quality of images from MRI also allows expedited detection of initial tumors, which contributes positively to better patient outcomes, for example, in the case of breast cancer screening.

Factors that influence radiation exposure in MRI and CT scans were studied and analyzed. The study aimed at identifying and analyzing these factors to appreciate the healthcare implications of radiation exposure in either modality. Thus, this helps to bring the knowledge base to bear on the management of radiation dose and optimization in medical imaging. The CT scans organ dose range at tens of mGy, with most of the values above the threshold level for deterministic effects like skin burns, epilation, and cataracts. However, most of the organ doses observed in CT scans were below the levels required for skin burns, epilation, and ocular cataracts but higher for the development of malignancies in patients exposed to tens of mGy.

4. Conclusion

Conclude the study connecting back to the aim of the study.

CT scans use ionizing radiation, while MRI scans use magnetic fields and radio waves, which do not pose the same radiation risks, Due to the absence of ionizing radiation, MRI scans are generally considered safer in terms of radiation exposure compared to CT scans. moreover Studies have shown that the radiation dose associated with MRI scans is significantly lower than that of CT scans, reinforcing the safety advantage of MRI in this regard.:

Based on the results of the study comparing the radiation dose in CT and MRI imaging techniques, the following recommendations are being provided:

1. Development and updating of clinical guidelines and protocols. These guidelines should better inform the healthcare professional about the selection of imaging modalities based on a consideration of the risk associated with radiation doses.
2. Radiology training and education: Incorporate the principles of radiation safety and optimization of dose into the training and education of radiologists, radiologic technologists, and other health providers associated with imaging procedure implementations. Increase their knowledge and awareness of management regarding radiation dose among these people.
3. Patient-centered decision making: Help the healthcare provider and the patient in decision making through information on the benefits, risks, and radiation exposure related to CT and MRI scans. It is also recommended that healthcare providers should obtain the information from patients on their case background and preferences before deciding which imaging modality is the most appropriate.
4. Dose monitoring and tracking: Implement ways of monitoring the dose and keep records of dose levels at CT scans. This includes using dose monitoring software, setting up dose databases, and regular audits on dose optimization. This will facilitate quality improvement initiatives and research on dose reduction strategies.
5. Search for new and non-ionizing imaging techniques: Support research and development of alternative imaging techniques that offer diagnostic information similar to that of CT scans, yet with lesser or no ionizing radiation. Consider further exploration of advancement in ultrasound, nuclear medicine, and other emerging imaging modalities that may present a safer alternative to CT scans for various indications.

REFERENCES

[1] Yaseen, H. F. (2022). Study the difference between the measurement of the radiation dose of MRI and CT scan. EUREKA: Health Sciences, (1), 63-68.

[2] Tariq, M., Siddiqi, A. A., Narejo, G. B., & Andleeb, S. (2019). A cross sectional study of tumors using bio-medical imaging modalities. Current Medical Imaging, 15(1), 66-73.

[3] Mazonakis, M., & Damilakis, J. (2016). Computed tomography: What and how does it measure?. European journal of radiology, 85(8), 1499-1504.

[4] Junn, J. C., Soderlund, K. A., & Glastonbury, C. M. (2021, January). Imaging of head and neck cancer with CT, MRI, and US. In Seminars in nuclear medicine (Vol. 51, No. 1, pp. 3-12). WB Saunders.

[5] Kumar, P., & Pandey, A. K. (2019). THE BIOLOGICAL EFFECTS OF RADIATION. Diagnostic Radiology: Advances in Imaging Technology, 407.

[6] Huda, W., & Tipnis, S. V. (2016). Doses metrics and patient age in CT. Radiation protection dosimetry, 168(3), 374-380.

[7] International Electrotechnical Commission. 2002. Medical electrical equipment. Part 2–44: Particular requirements for the safety of x-ray equipment for computed tomography. IEC publication No. 60601–60602–60644. Ed. 2.1. Geneva, Switzerland: International Electrotechnical Commission (IEC);

[8] Dixon RL. 2003 A new look at CT dose measurement: beyond CTDI. Med. Phys.;30:1272–1280

[9] Liu, X., Faes, L., Kale, A. U., Wagner, S. K., Fu, D. J., Bruynseels, A., ... & Denniston, A. K. (2019). A comparison of deep learning performance against health-care professionals in detecting diseases from medical imaging: a systematic review and meta-analysis. The lancet digital health, 1(6), e271-e297.

[10] International Commission on Radiological Protection 2007: Managing patient dose from multi detector computed tomography (MDCT), (ICRP Publication 102) Ann. ICRP.;37(1):1–79.

[11] Al-OThman, A. (2022). Radiation Dose Optimization for Routine Radiological Studies Using Computed Tomography: A Comparison Based on National Dose Reference Levels and Effective Dose Calculation (Doctoral dissertation, Alfaisal University (Saudi Arabia)).

[12] Ahmed, N. N. (2017). Estimation of organ doses and risk of cancer associated with CT examination.

[13] Fisher, D. R., & Fahey, F. H. (2017). Appropriate use of effective dose in radiation protection and risk assessment. Health physics, 113(2), 102-109.

[14] Bergen, R. V., Ryner, L. (2019). Assessing image artifacts from radiotherapy electromagnetic transponders with metal-artifact reduction imaging. Magnetic Resonance Imaging, 59, 137–142. doi: http://doi.org/10.1016/j.mri.2019.02.005

[15] Moolman, N., Mulla, F., Mdletshe, S. (2020). Radiographer knowledge and practice of paediatric radiation dose protocols in digital radiography in Gauteng. Radiography, 26 (2), 117–121. doi: http://doi.org/10.1016/j.radi.2019.09.006

[16] Hawarihewa, P. M., Satharasinghe, D., Amalaraj, T., Jeyasugiththan, J. (2021). An assessment of Sri Lankan radiographer's knowledge and awareness of radiation protection and imaging parameters related to patient dose and image quality in compu tedtomography (CT). Radiography. doi: http://doi.org/10.1016/j.radi.2021.10.010

[17] Smith-Bindman, R., Lṕez-Solano, N., Miglioretti, D., Flynn, M., & Seibert, J. A. (2020). Why Do Radiation Doses in CT Differ across Hospitals and Countries? Patient-Centered Outcomes Research Institute (PCORI). doi: http://doi.org/10.25302/07.2020. cd.13047043

[18] Bowen SR, Yuh WTC, Hippe DS, et al. 2018. Tumor radiomic heterogeneity: Multiparametric functional imaging to characterize variability and predict response following cervical cancer radiation therapy. J Magn Reson Imaging;47:1388–1396.

[19] Enkhbaatar NE, Inoue S, Yamamuro H, et al. 2018. MR Imaging with Apparent Diffusion Coefficient Histogram Analysis: Evaluation of Locally Advanced Rectal Cancer after Chemotherapy and Radiation Therapy. Radiology;288:129–137

[20] Dalah E, Erickson B, Oshima K, et al. 2018. Correlation of ADC With Pathological Treatment Response for Radiation Therapy of Pancreatic Cancer. Transl Oncol;11:391–398.

[21] Kasban, H., El-Bendary, M. A. M., & Salama, D. H. (2015). A comparative study of medical imaging techniques. International Journal of Information Science and Intelligent System, 4(2), 37-58.