Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2023 20(1):245-250. **OPEN ACCESS**

Computed tomography of the abdomen: an evaluation of the effective radiation dose and incidence of radiogenic colon cancer in north of Jordan

Laith Albadarneh[1], Azhar Abdul Rahman[1]*, Haytham Ahmad AL Ewaidat[2], Marwan Alshipli[3], Hamad Yahia Abu Mhanna[1], Thair Hussein Khazaalah[1], Ghassan Almurshedi[1], Abdallah Alsaid[1] and Esraa Abu Lubad[2] and Qurain Turki Alshammari[4]

[1]School of physics, Universiti Sains Malaysia, 11800 USM Minden Penang, **Malaysia**
[2]Department of Allied Medical Sciences-Radiology Technology, Faculty of Applied Medical Sciences, Jordan University of Science and Technology, Irbid 22110, **Jordan**
[3]Medical Imaging and Radiography Department, Aqaba University of Technology, Aqaba, **Jordan**
[4]Diagnostic Radiology Department, College of Applied Medical Sciences, University of Hail, Hail, **Saudi Arabia**

***Correspondence:** arazhar@usm.my **Received 12-02-2023, Revised: 25-03-2023, Accepted:28-03-2023 e-Published: 31-03-2023**

Computed Tomography (CT) is a widely used imaging modality that plays an essential role in the diagnosis and management of various diseases. However, CT scans expose patients to ionizing radiation, which can have long-term health risks, including the development of radiogenic cancer. Therefore, it is crucial to evaluate the effective radiation dose and incidence of radiogenic colon cancer in patients undergoing CT of the abdomen in the North of Jordan. This study aimed to evaluate the effective radiation dose and incidence of radiogenic colon cancer in patients underwent CT of the abdomen in the North of Jordan. A total of 1505 patients were included in the study, and their CT scans were analyzed to estimate the effective radiation dose. The incidence of radiogenic colon cancer was also evaluated in this population using a retrospective cohort study design. The results of this study indicate that the average effective radiation dose for CT of the abdomen in the North of Jordan were (12.75 mGy), (13.22 mGy), male and female, respectively, which is within the recommended range. Furthermore, the incidence of radiogenic colon cancer was 0.0107% and 0.0073% male and female respectively, which is relatively low compared to other studies. These findings suggest that the use of CT scans in the North of Jordan is relatively safe in terms of the effective radiation dose and the incidence of radiogenic colon cancer. However, it is important to note that despite the low incidence of radiogenic colon cancer in this study, the potential long-term risks associated with radiation exposure should not be overlooked. Therefore, it is recommended to optimize the radiation doses in CT scans and to continually monitor the potential long-term risks associated with radiation exposure. In conclusion, this study provides valuable insights into the effective radiation dose and incidence of radiogenic colon cancer in patients undergoing CT of the abdomen in the North of Jordan. These findings can help healthcare providers and policymakers make informed decisions regarding the use of CT scans in this region and highlight the importance of optimizing radiation doses to minimize potential long-term risks associated with radiation exposure. Also, this study recommends the establishment of criteria for justification and optimization, along with Diagnostic Reference Levels (DRLs).

Keywords: Computed Tomography (CT), multi-detector CT, volume CT dose index (CTDIvol), Dose length product (DLP), Diagnostic Reference Levels (DRLs).

INTRODUCTION

Computed Tomography (CT) is a commonly used diagnostic tool for the evaluation of abdominal pathologies. However, the associated ionizing radiation exposure has been a growing concern due to the potential risk of developing radiation-induced cancer, particularly in organs that are more sensitive to radiation, such as the colon. Since the seventies, CT has been used in the medical field, and attention began simultaneously (Khatonabadi et al.2013, Bardo and Brown, 2008 and Cho, 2013),CT scans are becoming more common, and patient doses are increasing (Zenone et al. 2009 and

Power et al .2016).According to a research by the National Council on Radiation Protection and Measurements (NCRP) (Protection, N.C.o.R. and Measurements. *Ionizing radiation exposure of the population of the United States*. 2009) concerns have been raised by the public and medical professionals about the dose that patient received during the radiological test. The International Commission on Radiological Protection (ICRP) created a measure of exposure called effective dose (E) to account for the uncertainties associated with radiation's possible effects on living tissue (cancer and genetic effects). In diagnostic radiology, in order to assess potential risks, an effective dosage is the most appropriate dose description of non-uniform whole-body exposure to ionizing radiation(Mettler et al.2008, Christner et al.2009) .When calculating the danger of low-level ionizing radiation exposure, several studies utilize the suggestion from the Biological Effects of Ionizing Radiation 7th report (Phase, 2006 , Hall and Brenner 2008 and Brenner et al.2007). In the same publication, both the absorbed dosage and the risk prediction for each organ were included. Each patients' risk profiles will vary depending on factors including their age and gender, which may cause the detrimental effect to differ in some situations and for a particular group (Bernieret al.2015).

Studies have shown that CT scans of the abdomen result in a higher effective radiation dose than other diagnostic imaging modalities. According to a study conducted by (Flohr ,2012), the effective radiation dose of a routine abdominal CT scan can range from 7 to 15 mSv, which is higher than the annual natural background radiation dose in most countries. In a retrospective cohort study by Mathews et al. 2013) the incidence of colon cancer was examined in a large cohort of patients who had received abdominal CT scans. The study included over 600,000 patients, and the results showed a significant association between increasing radiation exposure and the risk of developing colon cancer. Several studies has investigated the effective radiation dose and the risk of developing radiogenic colon cancer in different populations. However, there is a paucity of data on the incidence of radiogenic colon cancer and effective radiation dose in North of Jordan.

This study aims to evaluate the effective radiation dose and the incidence of radiogenic colon cancer in patients underwent CT scans of the abdomen in North of Jordan. Additionally, the study aims to provide a better understanding of the potential risks associated with the use of CT scans and to identify strategies to minimize radiation exposure while still obtaining diagnostic images, which may inform decisions regarding the use of different scanning technologies.

MATERIALS AND METHODS

The study was conducted as an establishment study between May 2020 and June 2022 in various hospitals across North Jordan, including private, military, and government hospitals, covering almost all hospitals in the region. Permission was obtained from the Jordanian Ministry of Health, the Directorate of Royal Medical Services, and some private hospitals to collect data from the CT department of their hospitals. The data were collected retrospectively from the Picture Archiving and Communication System (PACS) of each hospital. The data collected included demographic information, CT scan indications, scanning parameters. The study was approved by the Institutional Research Board (IRB) under the number 640-2020. Patient consent was not required as the data were obtained retrospectively from the PACS.(1504) patients were included in this study with (903) male and (601) female, scanning regardless of the protocol used for examination in different centers. All the participants are adults (≥18 years), CT scans without a dosage report were also disqualified.

2.2 Data Collection

The multidetector-slice and single-slice CT scanners from Philips, Toshiba, General Electric GE, and Siemens were used in hospitals in north of Jordan, and the dose indices from each CT scan of the abdomen examinations were (CTDIvol), (kVp), (mAs) and (DLP) values were collected.

2.3 Effective Dose

Organ dosages may be weighted or equivalent. The equivalent dosage of a projected output is the dose each organ gets during the initial pass. E binding to a certain organ determines the weighted equivalent dosage. Tissue weighting factor coefficients are a function of tube voltage (kVp), scan area, age, and population averages (Charles,2008 and Deak et al.2008). Patients grouped into similar age groups to the ICRP adult phantom. Multiplying DLP values by tissue-weighted coefficients yielded the effective doses:

$$E = DLP.E_{DLP}$$

E is the effective dosage, DLP dose length product, E DLP tissue-weighted coefficients.

Table 1: Conversion factor (Deak et al.2010).

Adult Tube voltage	EDlp (mSv) Abdomen
80	0.0151
100	0.0151
120	0.0153
140	0.0155
Mean	0.0153

2.4 Statistical Analysis

The collected data were analyzed using Microsoft Excel software. Descriptive statistics such as mean, standard deviation, and standard deviation were used to describe the data. The effective radiation dose was estimated using the CT dose index (CTDI) and dose length product (DLP) values. The incidence of radiogenic stomach cancer was estimated by multiplied average effective dosage received by each patient by the standardized National Academy of Sciences Biologic Effects of Ionizing Radiation BEIR VII conversion factor.

RESULTS

Table 2 and Chart 1 present further information on the data analysis. According to Table 2 and Chart 1, Female patients had higher CTDIvol and DLP (DLP= CTDIvol ×scan length) than male with (21.99715 mGy) and (864.59 mGy.cm), respectively. While male patients in north of Jordan had (20.80 mGy) and (833.84 mGy.cm) CTDIvol and DLP, respectively. The mean effective dosage E mSv was calculated. Chart 2 illustrates the mean effective dose based on gender. It indicates that the effective dose received by female patients higher than male patients with (13.22 mSv) and (12.75 mSv), respectively. In Table 2, mAs, kVp, CTDIvol (mGy), DLP (mGy.cm) and effective dose (mSv) values for scanned patients are listed.

3.2 Lifetime Time Risk Estimation

The incidence rateof colon cancer in female was 7 persons per 100,000 abdomen examination while the incidence rate of colon cancer for male was 11 per 100,000 abdomen examination.

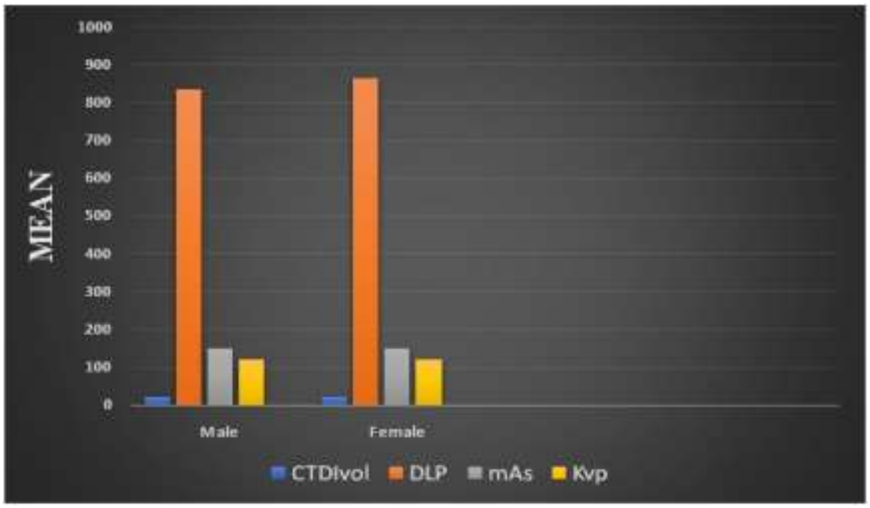

Chart 1:Parameters value based on gender.

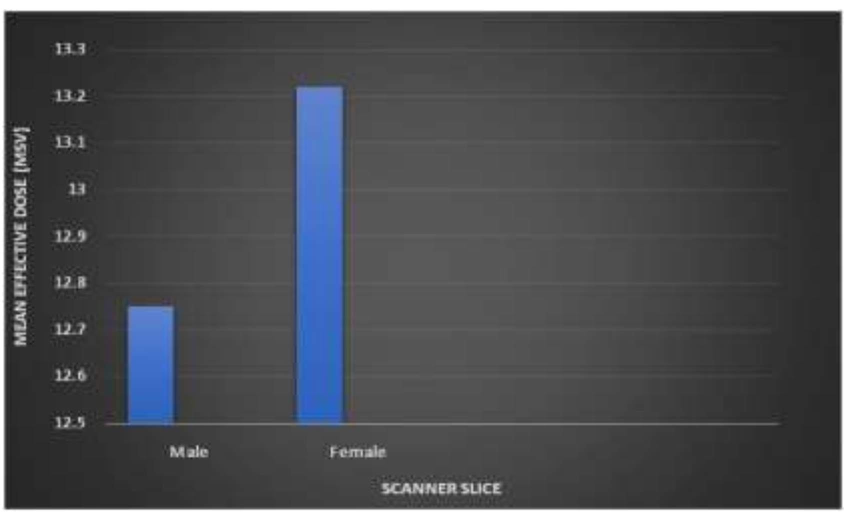

Chart 2: Effective dose related to gender.

Table 2: (CTDLvol), (mAs), (Kvp) and (DLP) values.

	Male						Female					
	CTDIvol (mGy)	DLP (mGycm)	mAs	Kvp	Effective dose (mSv)	Colon Dose (mSv)	CTDIvol (mGy)	DLP (mGycm)	mAs	Kvp	Effective Dose (mSv)	Colon Dose (mSv)
Mean	20.80	833.84	150.96	120	12.75	9.18	21.99	864.59	150.99	120	13.22	9.52
Mode	22	942	168.02	120			22	1506.23	143.35	120		
Median	18.8	755	148.60	120			19.1	770	150.60	120		
Standard deviation	9.50	375.14	17.37	0			10.70	373.49	16.71	0		
Range	48.7	2644.1	176.59	0			49.1	2294.1	146.30	0		
Minimum	9	5.9	103.40	120			8.6	5.9	103.69	120		

DISCUSSION

Computed Tomography (CT) is a widely used diagnostic imaging modality that provides detailed images of the abdomen. However, the use of CT scans raises concerns about the risk of radiation exposure, which can lead to an increased incidence of cancer. In addition, there is a possibility of radiogenic colon cancer, which can be caused by the high radiation doses delivered during abdominal CT scans. This issue has been studied in different regions. In this discussion, we will evaluate the effective radiation dose and incidence of colon cancer associated with CT scans of the abdomen for adult patients (over the age of 18) in north of Jordan.

Effective doses (mSv) of adult patients were computed during abdomen CT examinations. The distribution of patients was (903) male and (601) female. (Table 2) displays analysis of parameters, effective dose and Colon dose during abdomen CT examination. The parameter was sorted by gender. The tube voltage (kVp) was 120 and the tube current (mA) was from 103 to 280 mAs.

There are differences in DLP, between male and female patients and this is because of the specific technical parameters used, various patient sizes, slice scanner number and site-specific techniques that include selecting several technical factors to address the same clinical question. Consequently, larger doses are associated with better quality diagnostic results. (Al Ewaidat et al.2018).Using state-of-the-art image noise reduction filters can help with this issue (Alis kan & Evik, 2018). In a recent study, researchers employed artificial neural networks, a relatively new noise-filtering technique, to successfully identify noisy pixels. By using these filtering methods, we can lower mAs without sacrificing image resolution.

Chart 2 shows that the effective dose of female patients higher than male patients. This is because of different scanners as (Al Ewaidat et al. 2018)reported higher slice numbers result in better image quality with higher doses received by patients. These results are consistent with other research reported that (Pera, C.M., et al.2016 and Karim et al.2016)results showed that the radiation dosage from 64-slice MSCT was higher than that from 16-slice MSCT.

Also, in Table 3, effective dosages are compared to prior research (Matsunaga et al.2019, Smith-Bindman, R., et al.2015) .Table 3shows that the effective dose for the abdomen is higher than(Matsunaga et al.2019]Compared to Smith-Bindman et al.2015). Also, scan range, slice thickness, pitch and exposure characteristics contribute to the variances. All the investigations came to the same conclusion: effective doses during the abdomen CT are within the acceptable range of values

Table 3: Compared of effective dose with past study.

	Male	Female	[22]	[23]
Abdomen	12.75	13.22	10	17

The FDA has suggested the ALARA approach to lower radiation exposures in the population without significantly affecting image quality (as low as reasonably achievable) Feiga, 2002. Intense adjustments to the radiation dosage are possible by optimizing these controllable factors without sacrificing image quality Fearon,2009. Other measures to optimize scanning protocols include lowering the amount of test repetitions primarily caused by motion artifacts. The main goal of BEIR VII was to create the most precise risk assessment for exposure to low-dose LET; also, the Lifetime Attributable Risk (LAR), which indicates the incidence of cancer risk above the base rate, is the primary chance metric that should be used for estimating the risk of developing deadly cancer.

The risk of colon cancer incidence among male who had abdomen CT scans was greater than among females. For abdomen CT the incidence rate was one cancer incidence per (14285) and (9090) abdomen CT examination (male and female), respectively. This indicate that must implantation of particular criteria for justification and optimization for male patients. Because of technological advancements in computed tomography (CT) equipment, relatively easy picture capture with short scanning times, and the introduction of CT detectors with a large dynamic range, the usage of image acquisition parameters has heightened the risk of overexposure. Limits on radiation exposure in CT scanners are mostly due to the X-ray tube, not the image receptor (detectors).

Decreases in dosage are required to reduce radiogenic risk. Advanced dosage reduction strategies and image processing software are now standard in modern CT systems. Hence, educating workers on the risks associated with taking unnecessary chances is of utmost importance.

In conclusion, CT scans are an essential tool for diagnosing and treating medical conditions. However, the risks associated with radiation exposure should not be ignored. Radiologists and other healthcare providers should strive to use the lowest radiation dose protocols possible to minimize the risks associated with CT scans. Additionally, patients should be made aware of the risks associated with radiation exposure and be given the opportunity to make informed decisions regarding their health.

CONCLUSION

In conclusion, in northern Jordan, the effective dosage from abdomen CT scans was below safe limits but the risk from CT still exists because of its increased usage every year. The results showed that the risk of incidence colon cancer for male patients in CT abdomen scans is higher than for female patients. Therefore, this study recommended the implantation of particular criteria for justification and optimization and focused on male to reduce the risk of colon cancer incidence due to the abdomen CT examination. The radiographers can try to decrease the dose to patients and higher their knowledge about the risks due to CT examinations. Also, a benefit risk should be carefully considered. This work recommended the establishment of particular criteria for justification and optimization and Diagnostic Reference Level (DRL) to decrease the radiation risk. In summary, CT scans remain an important tool for medical diagnosis, but efforts should be made to minimize radiation exposure and reduce the potential risk of radiogenic cancer associated with the use of CT scans. However, it is important to note that the risk of developing radiogenic colon cancer may vary depending on several factors, such as age, sex, and underlying medical conditions. Therefore, further studies are needed to evaluate the risk of developing radiogenic stomach cancer in different populations.

This study had several limitations. Firstly, the study was conducted retrospectively, and there was no control group. Secondly, the sample size was relatively small, and the study was limited to only North of Jordan. Therefore, the results may not be generalizable to other populations. Finally, the study was limited to the evaluation of the effective radiation dose and incidence of radiogenic colon cancer and did not consider other potential risks associated with CT scans.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEDGEMENT

The authors take the opportunity to thank all the participants of this study and staff in radiology department at the Jordanian Hospitals.

AUTHOR CONTRIBUTIONS

LA. Write and perform the measurements, AAR, HAA, and EAL were involved in planning and supervised the work, LA, MA,HYA Collect data, performed the analysis, HK, GA, and AL drafted the manuscript and designed the figures. LKA and Professor QTA aided in interpreting the results and worked on the manuscript. All authors discussed the results and commented on the manuscript.

REFERENCES

Al Ewaidat, H., et al., *Assessment of radiation dose and image quality of multidetector computed tomography.* Iranian Journal of Radiology, 2018. 15(3).

Al Ewaidat, H., et al., *Radiation dose and image quality in adult computed tomography scans.* Journal of Medical Imaging and Health Informatics, 2018. 8(2): p. 223-231.

Bardo, D.M. and P. Brown, *Cardiac multidetector computed tomography: basic physics of image acquisition and clinical applications.* Curr Cardiol Rev, 2008. 4(3): p. 231-43.

Bernier, M.-O., et al., *Potential cancer risk associated with CT scans: review of epidemiological studies and ongoing studies.* Progress in Nuclear Energy, 2015. 84: p. 116-119.

Brenner, D., *EJJNEJ o. M. Hall.* Computed tomography—an increasing source of radiation exposure, 2007. 357(22): p. 2277-2284.

Charles, M.W., *ICRP Publication 103: Recommendations of the ICRP*. 2008, Oxford University Press.

Cho, P.K., *The development of a diagnostic reference level on patient dose for head computed tomographyangiography examinations in Korea.* Radiat Prot Dosimetry, 2013. 154(4): p. 505-9.

Christner, J.A., J.M. Kofler, and C.H. McCollough, *FOCUS ON.* medicine, 2009. 3: p. 5.

Deak, P.D., Y. Smal, and W.A. Kalender, *Multisection CT protocols: sex-and age-specific conversion factors used to determine effective dose from dose-length product.* Radiology, 2010. 257(1): p. 158-166.

Fearon, T., *CT dose parameters and their limitations.* Pediatric radiology, 2002. 32(4): p. 246-249.

Feigal, D.W., *FDA public health notification: reducing radiation risk from computed tomography for pediatric and small adult patients.* International journal of trauma nursing, 2002. 8(1): p. 1-2.

Flohr, T., *Multi-detector row CT–recent developments, radiation dose and dose reduction technologies.* Radiation dose from multidetector CT, 2012: p. 3-19.

Hall, E. and D. Brenner, *Cancer risks from diagnostic radiology.* The British journal of radiology, 2008. 81(965): p. 362-378.

Karim, M., et al., *Evaluating organ dose and radiation risk of routine CT examinations in Johor Malaysia.* Sains Malaysiana, 2016. 45(4): p. 567-573.

Khatonabadi, M., et al., *The feasibility of a regional CTDIvol to estimate organ dose from tube current modulated CT exams.* Med Phys, 2013. 40(5): p. 051903.

Mathews, J.D., et al., *Cancer risk in 680 000 people exposed to computed tomography scans in childhood or adolescence: data linkage study of 11 million Australians.* Bmj, 2013. 346.

Matsunaga, Y., et al., *Diagnostic reference levels and achievable doses for common computed tomography examinations: results from the Japanese nationwide dose survey.* The British journal of radiology, 2019. 92(1094): p. 20180290.

Mettler Jr, F.A., et al., *Effective doses in radiology and diagnostic nuclear medicine: a catalog.* Radiology, 2008. 248(1): p. 254-263.

Pera, C.M., et al., *Comparison of radiation dose in abdomen-pelvis and trunk imaging between 64 slice and 16 slice CT.* Physica Medica, 2016. 32: p. 295.

Phase, B.V., *Health risks from exposure to low levels of ionizing radiation.* Washington, DC: The British Institute of Radiology, 2006.

Power, S.P., et al., *Computed tomography and patient risk: Facts, perceptions and uncertainties.* World J Radiol, 2016. 8(12): p. 902-915.

Protection, N.C.o.R. and Measurements. *Ionizing radiation exposure of the population of the United States*. 2009. National Council on Radiation Protection and Measurements.

Smith-Bindman, R., et al., *Radiation doses in consecutive CT examinations from five University of California Medical Centers.* Radiology, 2015. 277(1): p. 134.

Tsapaki, V., et al., *Dose reduction in CT while maintaining diagnostic confidence: diagnostic reference levels at routine head, chest, and abdominal CT—IAEA-coordinated research project.* Radiology, 2006. 240(3): p. 828-834.

Zenone, F., et al., *Effective dose delivered by conventional radiology to Aosta Valley population between 2002 and 2009.* Br J Radiol, 2012. 85(1015): p. e330-8.