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Assessment of radiation risks in adult CT brain procedures in Morocco: A multihospital study in rabat region

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ABSTRACT

The objective of this investigation was to assess the radiation dose of patients undergoing CT brain examinations across three distinct modalities of CT scanners (16 slices, 64 slices, and 128 slices), as well as to analyze the associated biological effects within the context of Moroccan hospitals. A total of 150 patients participated in CT brain examinations conducted at three separate hospitals in Morocco. Data were obtained from a total of 50 CT scans performed in each hospital. The data that collected for For each examination included scanner acquisition parameters, number of series, use of the contrast medium, and rotation time as well as slice thickness, the displayed Computed Tomography Dose Index (CTDIvol) and the Dose Length Product (DLP). The assessment of cancer and hereditary risks was conducted using conversion factors provided by the International Commission on Radiological Protection (ICRP). The patients included in this study were an average age of the 56.33 years ± 20.70 years. The average radiation doses for CT brain scans were determined to be 695.61 mGy·cm ± 48.62 mGy·cm for 16 slice scanners, 890.83 mGy·cm ± 56.52 mGy·cm for 64 slice scanners, and 834.05 mGy·cm ± 161.58 mGy·cm for 128-slice scanners. The calculated patient cancer risks per procedure ranged from 9.10 per 10^5 CT to 11.75 per 10^5 CT procedures, with rates of 9.10 per 10^5 CT, 11 per 10^5 CT, and 11.75 per 10^5 CT procedures observed for 16-slice, 64-slice, and 128-slice scanners, respectively. Meanwhile, patient hereditary risks ranged from 3.31 per million to 4.27 per million CT procedures, with corresponding rates of 3.31, 4, and 4.27 for 16 slice, 64 slice, and 128 slice scanners, respectively.

Keywords: CT brain, DRL assessments, radiation risks, cancer and heredity risks

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INTRODUCTION

Medical imaging plays a crucial role in the identification, assessment, and management of various medical conditions. Approximately 3.6 billion diagnostic radiological procedures are performed around the world each year. Although the use of ionizing radiation for medical purposes offers m any b enefits, it can also increase the risk of cancer later in life. Where more radiation is used than is necessary to provide a clinical diagnosis, the patient can incur an increased risk but no additional benefit. Ideally, medical imaging procedures should be performed only when well justified and should use the lowest possible amount of radiation necessary to provide an image quality that is sufficient for diagnosing disease or injury [1]. In the last decade, the number of CT machines has increasedand consequently also the CT examinations during the past few years, the usage of CT scan has become a national trend in emergency departments [2]. Computed tomography plays an expanding role in diagnosing acute and chronic diseases as well as life-threatening diseases such as stroke, head injury, major trauma, heart disease, abdominal pain, pulmonary embolism, severe chest pain, and renal abnormalities [3]. Computed tomography risks are small but if these small risks are produced by million numbers of scans, they may drive into serious public health concerns in the future [4]. The International Commission on Radiological Protection (ICRP) has adjusted the nominal radiological detriment coefficients for cancer and hereditary effects as follows: 5.5×10^{-2} and 0.2×10^{-2} Sv^{-1} for the whole population [5]. Having an awareness of typical dose levels enables CT practitioners to promptly recognize and rectify any protocols that do not adhere to the ALARA principle (As Low As Reasonably Achievable principle), thus improving radiographic procedures.

The limited research on medical radiation exposure in Morocco, coupled with the absence of prior studies examining absorbed doses for different Computed Tomography (CT) scans and examinations, served as the impetus for undertaking the present study [6].

The objective of this study is to assess the radiation dose received by patients undergoing CT examinations across three modalities of CT scanners (16 slices, 64 slices, and 128 slices), as well as to analyze the associated biological effects.

MATERIAL AND METHOD

This prospective study was conducted across three hospitals in Morocco. Data utilized in this research were obtained from the radiology departments of these hospitals situated in the Rabat-Salé Region. Technical specifications of CT machines are regrouped in table 1. The CT machines undergo regular quality control assessments, ensuring that all operational parameters remain within acceptable limits.

Tab. 1. Summary of characteristic for the CT systems used in this study

Hospital (H) Num	Hospital Reference	CT Device (Make/Model)	Number of Slices	Rot. Time (s)	Phantom (cm)	AEC system
H1	H1-sale-CHP-MA	Siemens somatom scope	16 slices	1 .5 s	16 cm	CARE Dose 4D
H2	H2-sale-HP	Philips ingenuity core	64 slices	0.5 s	16 cm	DoseRight
H3	H3-rab-chr-MY	Hitachi scenaria	128 slices	0.5 s	16 cm	Intelli IP

Patient data

A total of 150 patients undergoing brain CT imaging procedures were included in this study, with 99 females and 51 males across three hospitals in Morocco, comprising 50 patients per hospital. Patient-specific data including age, gender, purpose of diagnostic examination, use of contrast media, and patient dose were collected. Additionally, various exposure-related parameters such as tube Kilovoltage (kV), tube current (mA), exposure time, slice thickness, table increment, number of slices, and scan start and end positions were documented. The CT Dose Index (CTDIvol) and Dose Length Product (DLP) were also recorded using the console of CT scanners from different manufacturers: a SIEMENS 16 slice CT scanner at Hospital-1 (H1), a PHILIPS 64 slice CT scanner at Hospital-2 (H2), and a HITACHI 128 slice CT scanner at Hospital-3 (H3).

Cancer and hereditary risks assessment

The overall cancer risk per procedure was calculated by multiplying the effective dose per Sievert (Sv) by the coefficient of 5.5×10^{-2} Sv^{-1} as per the formalism outlined in ICRP Publication 10[3] [5].

The risk for hereditary diseases up to the second generation per procedure was estimated by multiplying the effective dose expressed in Sievert (Sv) by the coefficient 0.2×10^{-2} Sv^{-1}, also in accordance with ICRP Publication 103 [5].

Statistical analysis

Data analysis was conducted utilizing statistical software, specifically SPSS version 21. The Dose Length Product (DLP) in mGy·cm and the Computed Tomography Dose Index (CTDIvol) in mGy were assessed to determine the third quartile values, serv-ing as reference values for Dose Reference Levels (DRLs) for each hospital as well as an overall average.

RESULTS

Data concerning 150 patients undergoing CT brain scans were collected, with 50 patients from each radiology department across the three hospitals participating in the study. Table 2 provides details on patient age, exposure parameters such as tube voltage (kV) and tube current-time product (mAs), as well as dosimetry parameters including Computed Tomography Dose Index (CTDIvol) and Dose Length Product (DLP) for the CT brain procedures conducted. The age range of the patients included in the study varied between 55.28 years ± 23.24 years and 57.68 years ± 19.25 years, with a mean age of 56.33 years ± 20.70 years.

Regarding the exposure parameters used, all three hospitals employed a consistent voltage of 120 kV for H2 and H3, while H1 utilized a slightly higher voltage of 130 kV. The current settings ranged from 168 to 345, with an average of 263 mAs being noted. In terms of dosimetry, the Computed Tomography Dose Index Volume (CTDIvol) for each sequence was observed to fluctuate between 39.78 and 44.46 mGy, averaging at 41.99 mGy. Additionally, the Dose Length Product (DLP) for each scan showed a variation from 695.61 to 890.83 mGy.cm, with an average recorded at 806.83 mGy.cm.

The Effective dose (E) received per patient during a brain CT scan varies between (1.65 ± 0.14) and (2.13 ± 0.13) mSv with a mean value of (1.93 ± 0.32) mSv.

The distribution of these values according to the hospital variable shows a difference in average effective dose of the order of 0.84 mSv, 0.53 mSv and 1.57 mSv for H1, H2 and H3. respectively (Table 3).

A significant variance in the effective doses across the three hospitals was identified by the ANOVA test, yielding a statistic FE mSv=48.87 with a significance level of $p \leq 0.01$.

The Effective dose (E) in Millisieverts (mSv) received by patients during brain CT scans has the potential to cause biological effects. The probabilities of cancer risk and genetic effects from each procedure across hospitals are detailed in Table 4. The likelihood of inducing cancer in patients per CT procedure ranges from 9.10 to 11.75 per 10^5 CT procedures. Specifically, this risk is quantified as 9.10, 11.75, and 11 per 10^5 CT procedures for 16-slice, 64-slice, and 128-slice scanners, respectively. The risk of genetic hereditary effects spans from 3.31 per million to 4.27 per million CT scans, with specific risks of 3.31, 4.27, and 4 for 16-slice, 64-slice, and 128-slice scanners.

Tab. 2. Patient average age and acquisition parameters per hospital

Hospital	Age ± SD (years)			kVp ± SD			mAs ± SD			CTDIvol ± SD (mGy)			DLP ± SD (mGy×cm)		
	Mean ± SD	Max	Min	Mean ± SD	Max	Min	Mean ± SD	Max	Min	Mean ± SD	Max	Min	Mean ± SD	Max	Min
H1	57.68 ± 19.25	88	16	130 ± 0.00	130	130	168.34 ± 9.46	188	150	39.78 ± 2.175	44.28	35.3	695.61 ± 48.62	780.61	564.43
H2	56.04 ± 19.62	81	15	120 ± 0.00	120	120	345.36 ± 18.66	382	298	44.46 ± 2.427	49.3	38.5	890.83 ± 56.25	995.5	772
H3	55.28 ± 23.24	99	15	120 ± 0.00	120	120	275.76 ± 42.46	362	199	41.71 ±6.468	58.5	28.4	834.05 ± 161.58	1197.6	539.5
All Hospitals	56.33 ± 20.70	89.33	15.33	123.33 ± 0.00	1230.33	1230.33	263.15 ± 23.53	310.66	215.66	41.99 ± 3.69	50.69	34.06	806.83 ± 88.82	991.23	625.31

Tab. 3. Presents the average and the range of effective doses E(mSv) for all procedures, detailed by hospital

E (mSv)/Hospital (H)	Mean ± SD	Max	Min	Range
H1	1.65 ± 0.14	1.87	1.02	0.88
H2	2.13 ± 0.13	2.38	1.85	0.53
H3	2 ± 0.38	2.87	1.29	1.57
All Hospitals	1.93 ± 0.32	2.87	1.02	1.84

Tab. 4. Presents the Cancer and hereditary risks for all procedures, detailed by hospital

Hospital (H)	Cancer Risk per 10^5 Procedures	Hereditary Risk per 10^6 Procedures
H1	9.1	3.31
H2	11.75	4.27
H3	11	4
All Hospitals	10.62	3.86

The patient dose, represented in terms of DLP (mGy·cm) and CTDIvol, is summarized in figures 1 and 2.

The DLP at Hospital 2 exceeds that at Hospital 3, which, in turn, surpasses the DLP at Hospital 1. The proposed DRLs were defined as 75th percentile of spreads for CT Dose Index-Volume (CTDIvol) and Dose Length Product (DLP)

Figure 3 shows a comparison of the patient's DRL for CT brain procedures between the three hospitals.

DISCUSSION

Analysis of brain imaging data from the three hospitals revealed that the mean value of CTDIvol ranged between 39.78 mGy ± 2.17 mGy and 44.46 mGy ± 2.42 mGy, with an overall mean of 41.99 mGy ± 3.69 mGy. This mean value is lower than that reported by Benmessaoud et al. in 2021 (58 mGy), and even lower than the recommended value by the ICRP (73.80 mGy) [5, 7]. The mean DLP was recorded as 806.83 mGy·cm ± 88.82 mGy·cm, with a minimum value of 539.5 mGy·cm and a maximum value of 1197.6 mGy·cm. This value is lower than the value found by Benmessaoud et al. in 2021 (1298 mGy·cm), and also lower than the recommended value by the International Commission on Radiological Protection (ICRP) Publication 103 (1050 mGy·cm) [5, 7].

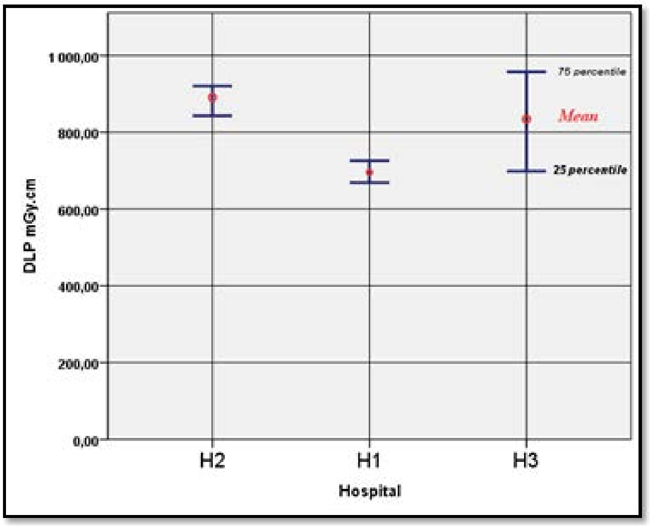

Fig. 1. Brain dose PDL per hospital

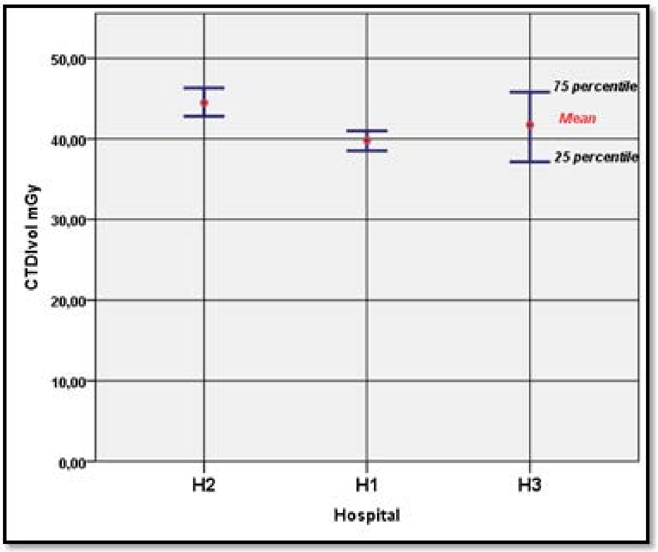

Fig. 2. CTDIvol per hospital

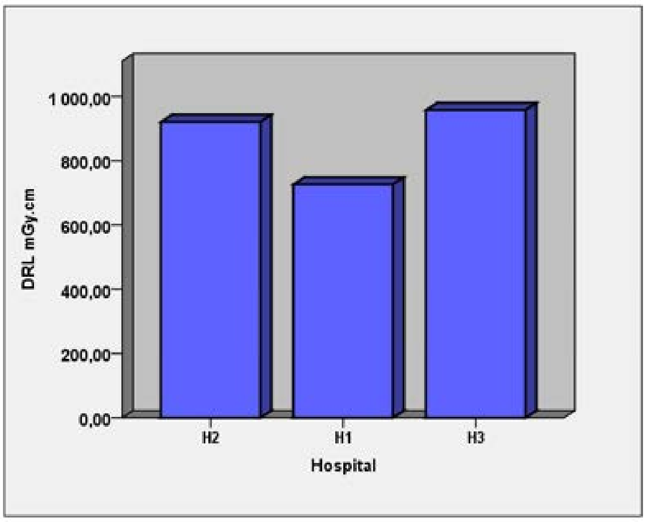

Fig. 3. Comparison of the DRL per hospital obtained in this study

Figure 3 indicates significant variation in DRL among different hospitals, and even within the same hospital. The higher values of CTDIvol and DLP at Hospital 2 are attributed to the use of higher tube current-time (345.36 mAs ± 18.66 mAs) on this scanner.
The effective dose calculated from the DLP using the conversion factor from ICRP Publication 103 exhibits variation, ranging from a minimum of 1.65 mSv ± 0.14 mSv to a maximum of 2.13 mSv ± 0.13 mSv, with an average of 1.93 mSv ± 0.32 mSv. All of our values are lower than those recommended by the ICRP (1 mSv^{-2} mSv)[5].

CONCLUSION

This prospective multicenter study conducted across three hospitals in Morocco, in the Rabat-Salé region, provided a comprehensive evaluation of radiation risks associated with adult CT brain procedures. Technical specifications of the CT machines used were meticulously documented, ensuring adherence to quality control standards. Analysis of patient data yielded valuable insights into exposure parameters, dose metrics, and associated risks. Our findings indicate significant variations in effective dose across different hospitals and even within the same hospital, underscoring the importance of standardization and optimization of CT protocols. Despite these variations, the effective doses observed in our study were generally lower than previously reported values and recommended dose reference levels, demonstrating a commitment to patient safety and radiation dose optimization.
Moreover, the calculated probabilities of cancer risk and hereditary effects per CT procedure emphasize the importance of understanding and mitigating potential biological consequences of radiation exposure. While our study revealed variations in these risks across different CT scanner types, it is essential for healthcare providers to remain vigilant in adopting protocols that prioritize patient safety and minimize radiation exposure.
Additionally, the data from our study can serve as Dose Reference Levels (DRLs) for our hospital until a more comprehensive study can be conducted in Morocco to establish national reference levels. This highlights the importance of ongoing research and collaboration to ensure safe and effective use of medical imaging modalities in clinical practice.
Overall, this study provides valuable insights into radiation risks associated with CT brain procedures in Morocco, highlighting areas for improvement in imaging protocols and patient care. Moving forward, continued research and collaboration will be crucial to ensure safe and effective utilization of medical imaging modalities in clinical practice.

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LIMITATIONS OF THE STUDY

The study's limitations include the inclusion of only adult patients and the use of CT from only three manufacturers. Another limitation encountered during the study was the challenge of finding additional defective CT devices, which restricts the generalizability of the findings.

CONFLICTS OF INTEREST

The authors state that they have no conflicts of interest to disclose.

REFERENCES

1. Nuclear Techniques in Human Health: Prevention, Diagnosis, Treatment. IAEA Bull. 2017:1-32.
2. Pearce MS, Salotti JA, Little MP, McHugh K, Lee C, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet. 2012;380:499-505.
3. Kocher KE, Meurer WJ, Fazel R, Scott PA, Krumholz HM, et al. National trends in use of computed tomography in the emergency department. Ann Emerg Med. 2011;58:452-462.
4. Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. N Engl J Med. 2007;357:2277-2284.
5. Protection R. ICRP publication 103. Ann ICRP. 2007;37:1-34.
6. Semghouli S, Amaoui B, El Kharras A, Shaim A, Hakam OK, et al. Physicians knowledge of radiation risk in prescribing CT imaging in Moroccan hospitals. Br J Appl Sci Technol. 2017;20:1-8.
7. Benmessaoud M, Housni A, Elmabrouki M, Essasnaoui F, Sadiki N, et al. Derivation of local diagnostic reference levels for common adult computed tomography examinations in Moroccan hospital. Radiat Prot Dosim. 2021;194:208-213.