



Journal Homepage: -www.journalijar.com
**INTERNATIONAL JOURNAL OF
 ADVANCED RESEARCH (IJAR)**

Article DOI:10.21474/IJAR01/ 4114
 DOI URL: <http://dx.doi.org/10.21474/IJAR01/ 4114>



RESEARCH ARTICLE

ESTABLISHMENT OF A DIAGNOSTIC REFERENCE LEVEL FOR BRAIN CT PROCEDURES IN MOROCCAN HOSPITALS.

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Manuscript Info

Manuscript History

Received: 08 March 2017
 Final Accepted: 0 April 2017
 Published: May 2017

Key words:-

CT examinations, radiation Risks, effective Dose, DRLs.

Abstract

Purpose: The aim of this study is to evaluate the patient doses during Computed Tomography (CT) brain procedures in order to establish a local diagnostic reference level (DRL) in some hospitals in Morocco.

Materials and methods: This study consisted of examining a total of 146 patients in six radiology departments in Morocco. The data were collected from CT Brain examinations at least of 20 CT scans per hospital. For each examination reported, CT acquisition parameters have included number of series, use of contrast medium, tube kV, tube current and rotation time, slice thickness, the displayed CT dose index ($CTDI_{vol}$) and the Dose Length Product (DLP).

Results: The patients were examined with their own department protocol using multislice CT (MSCT) quadruple slice, 16 and 64 CT slice from different manufacturers. The tube current time produce is used in two hospitals (H4-AGA-CNSS, H5-RAB-INO). The patients are exposed to a high dose up 200 mAs. One hospital uses a higher value up to 130 kV per CT brain. The tube tension defines penetration strength of the X ray beam. In terms of DLP, the average dose varies between 379,4 mGy.cm and 2434 mGy.cm. Therefore, a third quartile value of 1408 mGy.cm can be used as a first DRL local for CT brain procedure for adults. The DRL value found is higher than that found in other countries. It is 14% to 42 % higher compared to other studies. This value is as a preliminary study result, initiated to raise the attention concerning the prevention of unnecessary radiation dose for patients in CT imaging.

Conclusion: Doses received by patient during CT procedures vary from a radiology service to another and even at the same service. This large variation is due to patient clinical indication, CT system modality and image acquisition parameters.

The value of 1408 mGy.cm assessed as the first Moroccan DRL for CT brain procedure for adults is the highest value found so far in the

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literature. Therefore, in order to reduce this dose, corrective measures are required to eliminate unnecessary radiation dose that doesn't contribute to the overall profile of the patients. So, we recommend the normalisation of practices in the radiology departments by the development of such protocols and the promotion of educational and training programs in the field of radioprotection of patients.

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Introduction:-

The diagnosis of a wide range of diseases by the introduction of CT is considered as a valuable medical imaging technique. Several new clinical applications continue to emerge in medical field after the development of powerful CT machines. In the last decade, the number of CT machines have increased and hence the CT examinations [1]. While the protection of patient from unnecessary radiation exposure is recommended, the patient's benefit from an accurate diagnosis must be greater than the risk of radiation exposure [2]. When the image acquisition parameters are not properly attuned according to the patient size, an unproductive radiation exposure may be delivered to the patient [3]. Therefore, the reduction of the unnecessary exposure requires the application of the international commission of radiological protection (ICRP) principles of radiation protection. These principles specified that any medical imaging examination that necessitates exposure to ionizing radiation must be justified on the base of benefit to the patient. No practice requiring exposure to ionizing radiation must occur except if it generates adequate benefit to the exposed individual [4]. Once the radiological exam is justified, the technologist should use an optimum radiation exposure to accomplish the diagnostic task coherent with the requisite image quality. In order to evaluate the radiological practice, the ICRP recommended the establishment of diagnostic reference level (DRL) as the patient has no dose limit [5]. Since its first introduction in 1991, the establishment and application of DRL have formerly demonstrated beneficial tool for dose reduction in medical imaging procedure in order to reduce avoidable radiation exposure [6,7]. In Morocco, which classified among countries with health care level III [8], there are about 100 CT machines with various modalities and manufacturers listed from a single slice to 128 slices. At the centre of optimization is the establishment of DRLs, earliest proposed by the ICRP in 1996 [5] and later introduced into European legislation [6]. DRLs permit the identification of anomalously high dose levels by tuning an upper threshold, which standard dose levels should not overtake when adequate practice is applied. Immoderate doses in CT are not as easily identified through image quality affects, as in norm film-based radiography. Therefore, a consciousness of typical dose levels permits CT users to rapidly identify and address any protocols which do not meet the ALARA principle (as low as reasonably achievable), as a result ameliorate radiographic exercise.

The rare studies on medical radiation exposure in Morocco [9, 10] and the lack of a previous study on the assessment of the absorbed dose for various scans and examinations in computed tomography [11, 12, 13] prompted us to undertake this study. The purpose of this study is to evaluate the patient doses during CT brain procedures in order to establish a local diagnostic reference level DRL in some hospitals in Morocco.

Materials and Methods:-

The data used in this study were collected from six radiology services at various hospitals. Technical specifications of CT machines are regrouped in table 1. The machines are regularly controlled for quality measurements and all the measure parameters were within acceptable range.

Table 1:- Scanner System.

No	Hospital Reference	Manufacture	Modality (Number of Slice/detection)
1	H1-OUJ-HF	GE LIGHT SPEED	16
2	H2-RAB-CNRNS	GE LIGHT SPEED	04
3	H3-AGA-HM	GE LIGHT SPEED	64
4	H4-AGA-CNSS	GE LIGHT SPEED	04
5	H5-RAB-INO	SEIMENS	64
6	H6-AGA-HII	PHILIPS	02

Patient Data:-

A total of 146 patients (76 females' and 70 males) referred for brain CT Imaging procedures were considered in this study in six different hospitals in Morocco. Patient related parameters (age, gender, diagnostic examination purpose, body region, use of contrast media) and patient dose were collected. In addition, other exposure related parameters were taken in consideration such gantry tilt, tension (kV), tube current (mA), exposure time, slice thickness, table increment, number of slices, and start and end positions of scans on patient dose the displayed CT dose index (CTDI_{vol}) and the dose length product (DLP).

Statistical Analysis:-

The data were analyzed using Statistical Package for the Microsoft Office Excel 2007. DLP (mGy.cm) and CTDI_{vol} (mGy) were analysed to obtain the third quartile value as a reference value for DRL for each hospital and the overall average.

Results:-

A total of 146 CT brain procedures were performed during the data collection period in six different hospitals. Patient age per hospital is presented in table 2.

Table 2: patient age per hospital

Variable	Hospital Reference	Average age(Y)	Std. Deviation	Maximum	Minimum
Age	H1-OUJ-HF	58,15	08,75	82	43
	H2-RAB-CNRNS	51,50	21,00	90	17
	H3-AGA-HM	40,80	18,45	75	18
	H4-AGA-CNSS	46,44	19,63	77	22
	H5-RAB-INO	52,25	08,68	66	41
	H6-AGA-HII	44,62	18,64	80	21

Table 3 and 4 present the tube current time product (mAs) and radiation exposure parameters for tube voltage (kVp), respectively.

Table 3:- Tube current time (mAs) product per hospital.

Variable	Hospital Reference	Mean of tube current time	Std. Deviation	Maximum	Minimum
Tube current time (mAs).	H1-OUJ-HF	164,25	33,96	215,00	115,00
	H2-RAB-CNRNS	135,17	18,62	151,67	46,67
	H3-AGA-HM	151,65	58,54	315,00	70,00
	H4-AGA-CNSS	209,65	50,29	300,00	142,00
	H5-RAB-INO	320,00	00,00	320,00	320,00
	H6-AGA-HII	131,25	25,00	150,00	100,00

Table 4:- Patient tube voltage (kVp) product per hospital.

Variable	Hospital Reference	Mean	Std. Deviation	Maximum	Minimum
kVp	H1-OUJ-HF	120	0,00	120	120
	H2-RAB-CNRNS	140	0,00	140	140
	H3-AGA-HM	118	6,15	120	100
	H4-AGA-CNSS	120	0,00	120	120
	H5-RAB-INO	120	0,00	120	120
	H6-AGA-HII	120	0,00	120	120

The patient dose in terms of DLP (mGy.cm) and CTDI_{vol} are summarized in Tables 5 and 6 respectively.

Table 5:- Brain dose and DRL per hospital.

Variable	Hospital Reference	Mean	Std. Deviation	Maximum	Minimum	3 rd quartile
DLP (mGy.cm)	H1-OUJ-HF	715,50	178,73	1035	340	860,72
	H2-RAB-CNRNS	2434	719,82	2900	922	2602,96
	H3-AGA-HM	1135,76	607,88	3072	281	1305,29
	H4-AGA-CNSS	1211,49	186,98	1637,41	906,03	1294,30
	H5-RAB-INO	1854	178,59	2134	1584	2009,5
	H6-AGA-HII	339	56	450	267	379,4

Table 6:- CTDI_{vol} and DRL per procedure.

Variable	Hospital	Mean	Std. Deviation	Maximum	Minimum	3 rd quartile
CTDI _{vol} (mGy)	H1-OUJ-HF	19,16	7,74	32,56	7,10	23,66
	H2-RAB-CNRNS	117,84	39,20	119	49,64	119
	H3-AGA-HM	49,28	11,69	60,14	28,28	57,19
	H4-AGA-CNSS	74,34	10,57	95	59	75
	H5-RAB-INO	59,87	00,00	59,87	59,87	59,87
	H6-AGA-HII	22,3	00,00	22,3	22,3	22,3

Discussions:-

Since its emergence in 1971, the computed tomography scan has been the highest growing medical imaging system. It owns a short scanning time and a volumetric acquisition, so it allows the diagnosis of various diseases. To raise the benefit of the imaging procedure, it is obligatory to assess the parameters that affect CT dose for the patient.

In this study, a total of 6 CT machines were used, as shown in Table 1. 33% of the equipment is 64 slices and 04 slices each and 17% is 16 slices and double slice each.

The majority of patients are medium aged patients, except in the hospitals H1-OUJ-HF and H3-AGA-HM. It is important to note that there are a number of young patients with age range from 17 to 25 years. For this age group where patients are more sensitive than older groups, appropriate to long life expectancy.

With regard to CT imaging, there are number of patient characters and scan parameters that affect the dose and the quality of image. Several CT scan are controlled by users (e.g. kV, mAs, pitch). Other factors are characteristic to the scanner (e.g. detector efficiency, geometry). While others are intrinsic to patient (e.g., patient size, anatomy scanned). All these parameters are linked. A solid comprehension of how each parameter links to the others and involves both dose and image quality is fundamental for preserving the dose as low as reasonably achievable (ALARA). Consequently, an accurate assess of the factors affecting patient dose is obligatory.

Table 3 summarizes the tube current time used per hospital; it is well recognized that the radiation dose is relative to patient doses (CTDI_{vol}) throughout the radiological procedures. According to Table 3, all hospitals used a different average tube current even if some hospitals have the same machine. Despite there is no substantial difference of the majority of people head using different mean tube current is not justified. This reality proof that patients may had been exposed to needless radiations. The high tube current time produce is used in two hospitals (H4-AGA-CNSS, H5-RAB-INO). The patients are exposed to a high dose up to 200 mAs. When all parameters rest constant, the dose is proportional to tube current time product.

The tube voltage per hospital is presented in Table 4. Four hospitals out of six used a constant tube tension of 120kVp. One hospital use a higher value up to 130 per CT brain. Tube tension defines penetration strength of the x-ray beam. Consequently, higher energy x-rays have a higher probability than lower energy X-ray of traversing through the body and making signal at the detector. With all else being equal, upper kV will augment the ratio signal/ noise. For the similar scan parameters, varying the kV from 120 to 135 increases the dose by about 33% [14,15]. One dose is higher and more photons reaching the detectors permit a reduction in image noise, but the contrast of the tissues is also compromised [15].

This study shows great variation in the radiation dose to the patients as presented in Table 5. Usually these distinctions of doses are due to differences in acquisition parameters such as tube voltages, tube current, number of scan and repeated scans. In terms of DLP, the mean varies from 1230,50 mGy.cm to 1822,74 mGy.cm for 4 slice and 64 slice respectively. Table 5 and 6 shows large variation in patient dose among different hospitals and even in the same hospital. There may be reasons for these disagreements in clinical environment, of which the mainly significant causes for this diversity were due to clinical indication, CT scan modality and imaging protocol. This disagreement is larger if the practitioners are not well trained in CT imaging protocols and radiation dose optimisation aspects. These factors show substantially versus measures to present effective radiation protection. Consequently, it is essential to establish the least exposure doorstep that will deliver an adequate image quality in each application, suitably formulated in terms of clinical effectiveness.

Figure 1 shows a comparison of the patient's DRL for CT brain procedures between several countries. The value of DRL proposed in this study is higher by 14% to 42 % for the values established in the other countries. This value is a result of preliminary study initiated to raise the attention concerning the prevention of unnecessary radiation dose for patients in CT imaging. The Figure 1 indicates that there is a significant variation in DRL in diverse countries, and even in the same country from time to time due to progress in imaging technique. This study should be expanded to contain other surveys. The disposable data can be a baseline for more studies regarding dose optimisation. Based on our knowledge, no values have been suggested to date for DLP during CT brain procedure. Consequently, a third quartile value of 1408 mGy.cm can be used as a first DRL local for CT brain procedure for adults.

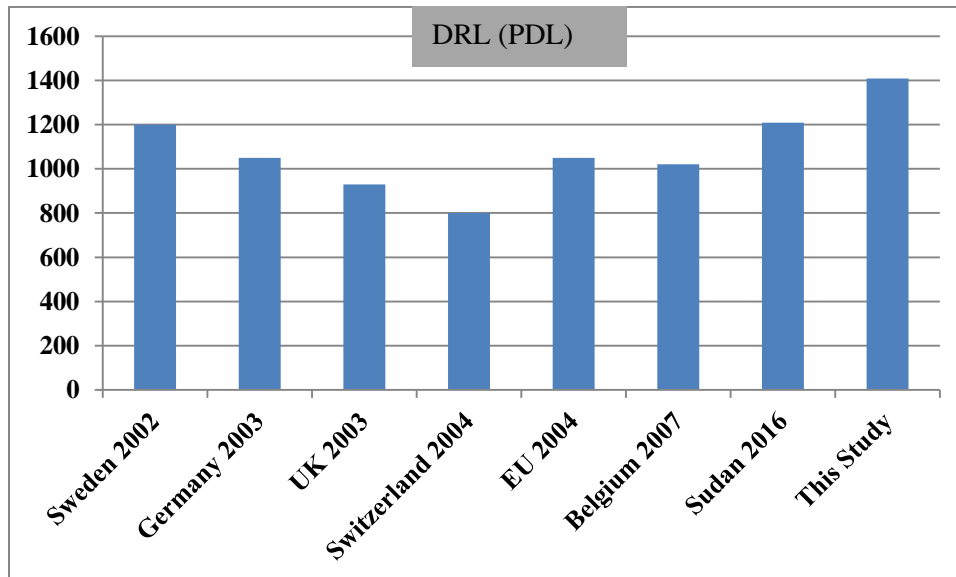


Figure 1:-Comparison of the DRL obtained in this study with other countries.

Conclusion:-

The purpose of this study was to evaluate the patient doses during CT brain procedures in order to establish a local diagnostic reference level DRL in six hospitals, therefore to deduct the first national DRL. This later assessed was to 1408 mGy.cm as the first Moroccan DRL for CT brain procedure for adults is higher to the equivalent result published for other countries. The high dose received by the patients in this study is attributed to the variation in technical parameters, clinical procedures, radiographic technique, untimely quality control program and perhaps the condition of the CT machine. Therefore, in order to reduce this dose, corrective measures are required in elimination unnecessary radiation that does not contribute to overall profile of the patients. Thus, we propose the unification of practices in our radiology departments by the development of the Moroccan protocols and investment in training in the field of patient radioprotection for our clinicians.

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