Assessment of the Knowledge of CT Scanner Operators on the Use of Dose Reduction Software Called Automatic Exposure Control (AEC) During a CT Scan

Eddy Fotso Kamdem (eddyfotsokamdem@yahoo.fr)
University of Dschang

Odette Ngano Samba
University of Dschang

Serge Abogo
National Social Insurance Fund Hospital

Joshua Tambe
Limbe Regional Hospital

Jean Claude Mballa Amougou
Yaoundé teaching Hospital

Emilienne Guegang
Yaoundé General Hospital

Odile Fernande Zeh
Yaounde Gynaeco-Obstetric and Pediatric Hospital

Célestine Nguemgne
Douala General Hospital

Narcisse Fidèle Nana Nwedjiwe
Douala General Hospital

Alain Jervé Fotue
University of Dschang

Research Article

Keywords: Dose reduction software, Care, Automatic exposure control , Medical imaging technicians, Radiation protection

Posted Date: August 9th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-754054/v1

Abstract

Objectif : Evaluate the knowledge of medical imaging technicians on the use of dose reduction software and the concept of patient radiation protection.

Materials and methods : Descriptive and analytical transversal study from January 1 to December 1, 2020, conducted in the radiology and medical imaging services of Cameroon's public and private hospitals with a CT scanner. It was the first study on this topic that was conducted in Cameroon. This study was conducted from a questionnaire distributed to all medical imaging technicians in 10 country hospitals relating to the notions of dose reduction software and patient radiation protection.

Results: 80 questionnaires were distributed and analyzed. The average age of medical imaging technicians was 30 years old. There were 32 women and 48 men. Most of the medical imaging technicians worked in private centers (n = 6). 75% of medical imaging technicians had been in practice for more than 5 years. 75% of medical imaging technicians gave the wrong answer regarding the use of dose reduction software. Finally, only a third of the practitioners had received training in patient radiation protection.

Conclusion : Although the majority of medical imaging technicians declares to take into account the dangers related to ionizing radiation during examinations, a broader dissemination of patient radiation protection training and the use of dose reduction software, particularly during the initial curriculum. Radiology technicians could be one of the solutions to improve the knowledge of hospital practitioners in patient radiation protection. However, the use of ionizing radiation, however, need to know and take into account the potential risks of radio-induced cancer linked to high X-ray doses.

1. Introduction

The medical imaging service must offer reliable and safe clinical outcomes while maximizing patient safety. In terms of radiation, the Alara Principle (As Low As Reasonably Achieventable), which consists in applying a dose as low as possible, is fundamental. Manufacturers introduce software to optimize doses received by patients. Siemens has long been at the forefront of reducing radiation. Its constant involvement and exclusive technological advances have made it the leader in low dose scanography [1]. There is no dose suitable for all patients on the same CT scanner. This is why the dose must systematically be adapted on a case-by-case basis, because each clinical case and each patient require, indeed, a personalized and precise level of dose. It is therefore important to determine the ideal dose to simply reduce doses. The ideal dose is defined as the right balance between irradiation and image quality.

The motivation of this study is the general lack of knowledge regarding the efficiency and the appropriate use of CT scanner automatic exposure control system. Today, practically all CT systems are delivered with automatic exposure control (AEC) systems operating with tube current modulation in three dimensions (combined modulation) [2]. AEC systems have a number of benefits: better control of the dose

absorbed by the patient, improved consistency of image quality among patients, reduction of certain image artefacts and reduced load on the X-ray tube, which increases its lifetime [3]. Several studies have assessed the AEC systems' potential for dose reduction (DR) when compared with the fixed tube current technique [4-7]. Automatic exposure control (AEC) system of Siemens equipment call Care Dose 4D is one effective technique contained in a CT Scan to decrease the amount of radiation dose [8]. Combination of Combined Applications to Reduce Exposure (CARE) Dose 4D and sinogram-affirmed iterative reconstruction (SAFIRE) decrease the radiation dose while maintaining image quality [9]. Each manufacture's AEC systems were designed for different purposes but mainly works by modulating the tube current to compensate for variations in attenuation of the patient's body, with a different method of operator control [10,11]. CARE kV combined with CARE Dose 4D techniques not only promises high quality images, but also decreases radiation dose [12]. CARE kV and CARE Dose4D can reduce radiation dose in CT scan of brain without loss of image quality [13]. Benito-González et al showed the Efficacity of the software "Care dose 4D / Care kV" to reduce radiation exposure in noninvasive CT angiogram [14]. CARE Dose 4D also modulates mAs through several mechanisms according to patient size and shape, whilst maintaining user-defined reference image quality [15] .

Scanner manufacturers each have dose reduction software in their computed tomography. Siemens For example, is a leader in computed tomography innovation on the principle of dose reduction. He introduced the solution in the 1990s, double source scanners at the beginning of the new millennium or Stellar detector over the next decade [1]. Adaptive dose shield technology, available on Somatom Definition Edge and Somatom Flash Definition, eliminates excessive pre-spiral and post-spiral irradiation (red zone). It is integrated into the new innovative straton radiogenic tube. The knowledge of these technologies gives several possibilities to medical imaging technicians to reduce the absorbed doses.

The purpose of this study was to assess the knowledge of radiology technicians on the use of dose reduction software and the concept of patient radiation protection during a examination on CT scanner.

2. Materials And Methods

2.1 Population

An analytical descriptive transverse study from January 1 to December 1, 2020 was conducted. Eighty questionnaires were handed over to all scanner manipulators (radiologist, technicians or engineers) in January 2020 in the 10 radiology and medical imaging services of Cameroon's public and private hospitals with a CT scanner. The questionnaires were distributed at their place of service and were filled by themselves. Manipulators who have never carried out a CT scan examination have been excluded from this study. These radiology manipulators were classified into 4 groups. Masters have a Master (Bac + 5) in radiological techniques, superior technicians in radiology and medical imaging (TSRIM) have a license (bac + 3) in radiological techniques, manipulators are those who have no university degree but have received training in the service in radiological techniques and radiologists who are doctors in

radiology. Study was carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from all participants.

2.2 Questionnaire

The questionnaire was developed from the data of the literature, in consultation with a radiologist and a medical physicist. He had three large parts. A first part analyzing the demographic data of the manipulator (age, sex, internal or senior, years of experience, belonging service, qualification, and country of training) and the risks associated with the use of X-rays at the CT scanner. A second part that assessed the knowledge of practitioners on the use of dose reduction software during a computed tomography examination and a third party requiring practitioners if they had already received patient radiation protection training.

2.3 Results analysis

The questionnaire was due to be returned to the medical imaging department by the end of April 2020. The results were analyzed anonymously. The processing of the data collected was done using Excel software. A threshold of 5% was considered significant.

Ethical considerations

Ethical approval was obtained from the Ethical Review Board of University of Dschang and some facilities of this study.

3. Results

3.1 Sociodemographic characteristics of manipulators

Eighty questionnaires distributed, Eighty were retrieved and analyzed, for an overall response rate of 100%. The average age of the manipulators was 30 years old. There were 32 women and 48 men, ie a sex ratio of 1.5 in favor of men. Most of the technicians (n = 56) worked in private centers (n = 6). 75% of manipulators had been in practice for more than 5 years. Those with more than 10 years of professional experience were 24 (30%). There were mainly 41 superior radiology and medical imaging technicians (TSRIM) or 51.25%. The number of masters was 20 or 25%, that of assistant manipulators 2 or 2.5% and 17 radiologists or 21.2%.

3.2 Questionnaire results

None of the hospitals studied did not have the information sheet of patients on the use of X-rays at the CT scanner room (Table 1). 75% of manipulators did not give the correct answer regarding the use of dose reduction software. On the other hand, only one-third of practitioners (26.6%) had received patient radiation protection training. All questions asked to radiologists were favorable.

L'AEC is a generic name for any technique aimed at optimizing dose utilization by adjusting the tube current in rea-time to accommodate differences in attenuation due to patient antomy, shape, and size [10]. Proportion of favorable responses according to the qualification of the manipulator and professional experience of the manipulator are presented in Table 2 and 3. The four most commun strategies use in our CT scanners are presented in Table 4.

These AEC trade names in table 4 represent the dose reduction softwares used in these different types of CT scanners.

4. Discussion

The main results of our study were the following; The 10 hospitals studied did not have an information sheet of patients on the use of X-rays at the CT scanner room and the notion of patient radiation protection during an examination; Regarding the use of dose reduction software, 75% of medical imaging technicians had not given the correct answer; One-third of practitioners had benefited from patient radiation protection training during their academic training. All questions asked to radiologists were favorable.

This study shows that efforts should be provided for improving clinical practice in medical imaging services in our hospitals. The use of these software during an exam can reduce the dose. Manufacturers offer these technologies not only to sell their device better but also to protect patients against the harmful effects of ionizing radiation. The balance between the dose and the quality of the image is this during an imperative in medical imaging. The particular attention we carried to the low dose is no longer enough. Our efforts must now focus on a good understanding of the ideal dose. The right dose is the reasonable balance between applied radiation, image quality and patient care. In order to help customers achieve this balance, Siemens Healthineers has introduced CARE Right. To help customers achieve this balance, Siemens offers Care Right that is based on three aspects: technology for an ideal dose, ideal dose levels and ideal dose management [1]. For some time now, iterative reconstruction has been a promising method of sensitive reduction of the dose without compromising on image quality. For innovation in the iterative reconstruction for obtaining an ideal dose, Siemens proposes Admire (Advanced Modelled Iterative Reconstruction), SAFIRE (Sinogram affirmed Iterative Reconstruction) that makes it possible to take advantage of iterative reconstruction while reducing the dose up to at 60%. Surpasses even that offered IRIS (Iterative Reconstruction in Image Space). Iris also provides excellent image quality at a reduced dose. Several other techniques are utised to reduce the dose to the scanner. CARE DOSE 4D makes it possible to adapt the dose according to the anatomy of the patient and its position during the

acquisition. Care KV automatically determines the appropriate voltage and acquisition parameters to obtain the ideal dose for the relevant review and user-defined image quality [1].

The CT Scanner is the most significant contributor to radiation dose on radiological examination, although the frequency of the examination is far below other modalities [16]. In order to control this radiation dose, manufactures of CT Scan have equipped their units with built-in software called Automatic Exposure Control (AEC). Sari et al showed the use of CARE Dose 4D software reduced dose of up to 54.34% while maintaining image quality. CARE Dose 4D (Siemens Healthineers, Erlangen, Germany) comprises a series of dose-saving technologies in which the tube current is adapted according to patient size, shape and density, whilst maintaining a user-defined reference image quality [17]. CARE Dose 4D provides the following: adaptation of mAs according to patient size based on the topogram (scout scan); angular modulation of the tube current to reflect patient shape; and z-modulation of the tube current to reflect patient shape (topogram-based modulation in a more fine-tuned manner). Computed tomography (CT) systems routinely use automatic exposure control (AEC), which modulates the tube current. However, for optimal use, there are several aspects of an AEC system that need to be considered. When optimising the CT radiation dose and image quality, the projection angle of the localiser, patient centring, protocol selection, scanning direction and the use of protective devices requires special attention [18]. Toshiba, Philips and General Electric (GE) use software such as Sure Exposure, Care Right and Auto or Smart mA to reduce the dose absorbed to the CT scanner like Siemens.

The manipulation of CT scanner in medical imaging services should be taken seriously. Each manipulator must master the technology present in the CT scanner it uses on a daily basis. Each CT scanner to its specificity in dose reduction procedures. A medical imaging technician who does not master the software on the CT scanner that he uses on a daily basis will always work with the acquisition parameters proposed by the CT scanner. Which will lead to patients from non-optimized doses. Training on CT scanner technology installed in your service will allow medical imaging technicians to better contribute to dose optimization during an examination.

5. Conclusion

This study outline that the automatic exposure control (AEC) systems can be used to obtain user-specified modifications to image quality or radiation exposure to the patient. It is essential that medical imaging technicians are aware of the differences between different CT systems, and such differences are useful when undertaking strategies for CT radiation dose optimisation. The kwnowlede of dose reduction software as Care Dose (Siemens), SureExposure(Toshiba), Auto or SmartmA (General Electric), Care Right (philips) are essentials to improve the clinical practice in CT scanner. So this survey shows that the use of the AEC systems is very useful in reducing the radiation dose.

Declarations

Acknowledgements

The authors wish to thank the medical imaging technicians for their valuable assistance in data collection.

Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

References

1. CARE Right - Committed to the Right Dose in CT, n.d. URL https://www.siemens-healthineers.com/no/computed-tomography/technologies-innovations/care-right (accessed 7.12.21).
2. McCollough, C. H., Bruesewitz, M. R. and Kofler, J. M. Jr. CT dose reduction and dose management tools: overview of available options. Radiographics. 26, 503–512 (2006).
3. Keat, N. CT scanner automatic exposure control systems. MHRA Evaluation Report 05016 (London, UK: Medicines and Healthcare products Regulatory Agency) (2005).
4. Rizzo, S., Kalra, M., Schmidt, B., Dalal, T., Suess, C., Flohr, T., Blake, M. and Saini, S. Comparison of angular and combined automatic tube current modulation techniques with constant tube current CT of the abdomen and pelvis. AJR Am. J. Roentgenol. 186, 673–679 (2006).
5. Papadakis, A. E., Perisinakis, K. and Damilakis, J. Automatic exposure control in pediatric and adult multidetector CTexaminations: a phantom study on dose reduction and image quality. Med. Phys. 35, 4567–4576 (2008).
6. Mulkens, T. H., Bellinck, P., Baeyaert, M., Ghysen, D., Van Dijck, X., Mussen, E., Venstermans, C. and Termote, J. L. Use of an automatic exposure control mechanism for dose optimization in multi-detector row CT examinations: clinical evaluation. Radiology. 237, 213–223 (2005).
7. Kalra, M. K., Rizzo, S. M. and Novelline, R. A. Reducing radiation dose in emergency computed tomography with automatic exposure control techniques. Emerg. Radiol. 11, 267–274 (2005).
8. Resmana, T., Darmini, D., Wijokongko, S., 2017. Analisis Image Noise dan Nilai Dosis Radiasi Penggunaan Aplikasi Care Dose 4D dan Non Care Dose 4D pada Pesawat MSCT Siemens. J. Imejing Diagn. JImeD 3, 258. https://doi.org/10.31983/jimed.v3i2.3196
9. Wang, L., Gong, S., Yang, J., Zhou, J., Xiao, J., Gu, J.-H., Yang, H., Zhu, J., He, B., 2018. CARE Dose 4D combined with sinogram-affirmed iterative reconstruction improved the image quality and reduced the radiation dose in low dose CT of the small intestine. J. Appl. Clin. Med. Phys. 20. https://doi.org/10.1002/acm2.12502
10. Shawna L. *et al.*, “CARE Dose 4D CT Automatic Exposure Control System: Physics Principles and Practical Hints. Radiological Society of North America,” Scientific Assembly and Annual Meeting,

November 25 - November 30, 2007 ,Chicago I.L., 2007. http://archive.rsna.org/2007/5011233.html Accessed February 28, 2020.

11. C. H. Lee *et al.*, “Radiation Dose Modulation Techniques in the Multidetector CT Era: From Basics to Practice,” Radio Graphics, 2008, vol. 28.
12. Kang, S.-L., Zeng, X.-C., Xie, X.-J., Han, D., 2013. CARE kV combined with CARE Dose 4D techniques for decreasing radiation dose of chest CT scanning in adult. Chin. J. Med. Imaging Technol. 29, 636–640.
13. Shah, P., Sharma, A., Gyawali, J., Paudel, S., Shrestha, S., Maharjan, S., 2018. Dose optimization in computed tomography of brain using CARE kV and CARE Dose 4D. https://doi.org/10.7577/radopen.3110
14. Benito-González, T., Sánchez-Gracián, C., Trinidad, C., Fernandez, D., Campos, A., Fiore, A., Fernandez, V., Bajo, A., Paz, E., Garriz, I., 2015. Efficacy of the software “Care dose 4D / Care kV” to reduce radiation exposure in noninvasive CT angiogram.
15. Hansen, S., Bebbington, N., 2020. Estimation of CARE Dose 4D quality reference mAs conversion factors for child to adult reference patient in child protocols on Siemens Symbia SPECT-CT systems. Nucl. Med. Commun. Publish Ahead of Print. https://doi.org/10.1097/MNM.0000000000001312
16. Sari, N., Suzana, M., Muslim, M., Muliyati, D., 2020. ANALYSIS OF THE EFFECT OF CARE DOSE 4D SOFTWARE USE ON IMAGE QUALITY AND RADIATION DOSE ON THE CT SCAN ABDOMEN. Spektra J. Fis. Dan Apl. 5, 31–40. https://doi.org/10.21009/SPEKTRA.051.04
17. Flohr T. CARE Dose 4D white paper. 2011. Available on request to a Siemens Healthcare representative.
18. Söderberg, M., 2015. Overview, practicaltips and potential pitfalls of using automatic exposure control in CT: Siemens CARE Dose 4D. Radiat. Prot. Dosimetry 169. https://doi.org/10.1093/rpd/ncv459

Tables

Table 1

Manipulators' responses (TSRIM, Master and Manipulator) to questions about dose reduction software and patient radiation protection

Questions	Results	
Knowledge of risks related to the use of ionizing radiation	Yes	61 (96,8%)
	Non	2 (3,1%)
Do you know the CT scanner dose reduction software	Yes	9 (14,2%)
	Non	54 (85,7%)
Have you received specific training on the use of dose reduction software?	Yes	0 (0%)
	Non	63 (100%)
Do you often use the dose reduction software for your CT scanner during an exam ?	Yes	9 (14,2%)
	Non	54 (85,7%)
Do you know the principles of radiation protection bases	Yes	61 (96,8%)
	Non	2 (3,1%)
Have you received specific training in radiation protection?	Yes	9 (14,2%)
	Non	54 (85,7%)
Make the radiation protection	Yes	61 (96,8%)
	Non	1 (85,7%)

Table 2

Proportion of favorable responses according to the qualification of the manipulator

Questions	manipulators (n=2)	TSRIM (n=41)	Masters (n=20)	Radiologists (n=17)	P-Value
Knowledge of risks related to the use of ionizing radiation	1 (50%)	41 (100%)	20 (100%)	17 (100%)	0,2
Do you know the CT scanner dose reduction software	0 (0%)	0 (0%)	0 (0%)	17 (100%)	
Have you received specific training on the use of dose reduction software?	0 (0%)	0 (0%)	0 (0%)	17 (100%)	
Do you often use the dose reduction software for your CT scanner during an exam ?	0 (0%)	20 (48,7%)	10 (50%)	17 (100%)	
Do you know the principles of radiation protection bases	1 (50%)	41 (100%)	20 (100%)	17 (100%)	
Have you received specific training in radiation protection?	0 (0%)	10 (24,3%)	5 (25%)	17 (100%)	
Make the radiation protection	2 (100%)	10 (24,3%)	20 (100%)	17 (100%)	

Table 3

Proportion of favorable responses according to the professional experience of the manipulator

Questions	Moins de 5 ans (n=5)	5-10 ans (n=20)	Plus de 10 ans (n=38)	P-Value
Knowledge of risks related to the use of ionizing radiation	4 (80%)	20 (100%)	38 (100%)	0,2
Do you know the CT scanner dose reduction software	0 (0%)	0 (0%)	0 (0%)	
Have you received specific training on the use of dose reduction software?	0 (0%)	0 (0%)	0 (0%)	
Do you often use the dose reduction software for your CT scanner during an exam ?	0 (0%)	5 (25%)	10 (26,3%)	
Do you know the principles of radiation protection bases	4 (80%)	20 (100%)	28 (73,6%)	
Have you received specific training in radiation protection?	1 (20%)	5 (25%)	10 (26,3%)	
Make the radiation protection	4 (80%)	20 (100%)	20 (100%)	

Table 4

Four most common dose reduction software in CT scanner

Manufacturer	AEC trade name	Image quality reference
Toshiba	SureExposure	Target image quality level
General Electric	Auto mA, Smart mA	Noise index
Siemens	Care Dose 4D	Quality reference effective mAs
Philips	DoseRight	Reference image