ISSN (Print) 1226-1750
ISSN (Online) 2233-6656
Journal of Magnetics 25(4), 644-648 (2020) https://doi.org/10.4283/JMAG.2020.25.4.644

An Analysis of Doses and Images of Mobile CT of High-Energy Electromagnetic Wave Area

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(Received 30 October 2020, Received in final form 9 December 2020, Accepted 10 December 2020)

The demand in medical field for Mobile Computed Tomography in high-energy electromagnetic area is exploding. To measure the distribution of exposure doses in abdomen inspection, this study placed 2 glass dosimeter elements on the entry point and exit point, respectively, 2-3 cm above the navel, the central point of abdominal inspection, and measured exposure doses in different parts. And, to reduce measurement errors, MDCT scanning was done 5 times. Acquired images were analyzed qualitatively to identify usefulness in medical treatment. Qualitative analysis of images was done about image contrast, lesion discovery rate, and clarity of border. Five specialists (2 medical doctors specializing radiology and 3 radiologists with working experiences over 10 years) were asked to classify the results on the 5-point scale (1 - very poor; 2 - poor; 3 - average; 4 - good; 5 - very good). In skull CT scanning, exposure doses measured with glass dosimeter were as follows: 21.4 ± 0.43 mGy by 4-MDCT; 13.7 ± 0.43 mGy by 128-MDCT; 5.02 ± 0.19 by Mobile CT, which shows that Mobile CT requires relatively lower dose to get meaningful images in diagnosis ($P < 0.05$). In skull CT scanning, the images acquired from MDCT and Mobile CT were graded on the 5-point Likert scale: 4-MDCT images got 3.50 point; 128-MDCT images got 4.43 point; Mobile CT images got 4.21 point. The 128-MDCT got the highest point, followed by 4-MDCT and Mobile CT. The difference was statistically significant ($P < 0.05$). The above findings show that Mobile CT is good for getting high-quality image and reducing radiation exposure doses. It seems that more hospitals will use Mobile CT.

Keywords : electromagnetic wave, image quality, exposure dose, glass dosimeter, laser element

1. Introduction

Recently, with the development of medical technology, and with the increasing attention to healthy life, life span has increased, and many countries, in particular, advanced countries have become aging societies. With such social and economic necessity, the demand in the medical field for Mobile Computed Tomography (Mobile CT) in the high-energy electromagnetic wave area has exploded [1, 2].

When doctors diagnose patients, diagnostic imaging devices using high-energy electromagnetic wave which provide accurate anatomical and functional images of human body without damaging tissues has taken up high proportion. Diagnostic imaging devices noninvasively inspecting inside of patient in 2- and 3-dimensions consist of X-ray generator and computed tomography (CT), etc. [3, 4]. CT inspection using radiation and X-ray has many benefits in getting diagnostic information, it is widely used in the medical field by developing the method of getting optimal images while minimizing dose to patients [6-9].

With such a purpose, Mobile Computed Tomography capable of getting good video images while reducing exposure radiation dose was developed, and has been used in hospitals. However, there have been few researches on dose information and evaluation and analysis of video images.

Glass dosimeter is the device to measure cumulative exposure dose, and the dose range is wide with 10 μGy-10 Gy. Its dose rate dependence is low, and its energy dependence is similar to that of film badge, and its fading of luminescent amount is very small. And, it is excellent in re-measurability and reproducibility. While it has a merit that it can be reused after heat treatment, it has demerits that it is influenced by pollutants like dust on table surface, and that it is mechanically weak [10, 11].

As a method to measure radiation exposure dose, it is

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possible to measure absorbed dose using physical body-tissue equivalent phantom, Thermo Luminescence Dosimeter (TLD), and glass dosimeter, and evaluate effective dose. As TLD has a limit that it can be read only one time, recently, exposure dose is generally measured by glass dosimeter [1, 12, 13].

This study was performed to provide dose management data which can be used in clinical treatment by measuring dose using glass dosimeter for Mobile CT, equipment to get video image with low dose using high-energy electromagnetic wave, and evaluating image quality.

2. Research Objects and Method

2.1. Materials and equipments

3.0T Low-dose Mobile CT used in the experiment is Phion CT scanner (NFR system, Korea) which can get images using narrow beam. Scanning condition is to for skull and extremities as shown in (Table 1, Fig. 1). To exposure dose of the subject, the whole human body phantom composed of body equivalent (Model PBU-31, Kyoto Kagaku, Japan) and glass dosimeter Dose Ace (Model GD-352M and FGD-1000, Asahi Techno Glass Cooperation, Shizuoka, Japan) were used (Fig. 2).

Table 1. Mobile CT scan parameter.

Parameter	Skull	Extremity
kVp	105	195
mA	10	10
Time (msec)	21.7	21.7
mAs_{eff}	39.06	39.06
Scan time (sec)	7.81	7.81
CTDIvol (mGy)	6.38	4.69
Reconstruction	Auto	Auto

Fig. 1. (Color online) Mobile tomography device.

Fig. 2. (Color online) Glass dosimeter elements.

2.2. Measurement of dose with glass dosimeter

Calibration of glass dosimeter was conducted using glass element where 6 mGy is projected using ^{137}Cs standard radiation source at the Japanese Radiation Standard Center. To measure the distribution of exposure doses in abdomen inspection, this study placed 2 glass dosimeter elements on the entry point and exit point, respectively, 2-3 cm above the navel, the central point of abdominal inspection, and measured exposure doses in different parts. And, to reduce measurement errors, MDCT scanning was done 5 times [14, 15].

2.3. Image evaluation

Acquired images were analyzed qualitatively to identify usefulness in medical treatment. Qualitative analysis of images was done about image contrast, lesion discovery rate, and clarity of border. Five specialists (2 medical doctors specializing radiology and 3 radiologists with working experiences over 10 years) were asked to classify the results on the 5-point scale (1 - very poor; 2 - poor; 3 - average; 4 - good; 5 - very good).

2.4. Statistical treatment and analysis

The data were analyzed using the SPSSWIN (Ver 13.0) program. The significance test of the means of exposure doses for the experimental group and the control group was done by t-test and ANOVA. The significance level of all the statistics was set at $P < 0.05$.

3. Findings and Discussion

3.1. Measurement and evaluation of Mobile CT X-ray doses

The body parts inspected by Mobile CT scanner are mainly skull and extremities. The body parts dealt with by this study are facial head and wrist bone parts. In addition, the CT equipment used in abdominal scanning

Table 2. Comparison of the 4,128 and Mobile CT with total dose.

Motality	4-MDCT	128-MDCT	MB-CT
Abdominal Exposure	35.8 ± 0.46	19.03 ± 0.25	-
Facial Expodure Dose (mGy)	21.4 ± 0.43	13.7 ± 0.43	5.02 ± 0.19
Wrist Expodure Dose (mGy)	-	-	3.42 ± 0.17
p-value	< 0.05	< 0.05	< 0.05

to compare with such dose values was CT Aquilion - CX (Thoshiba Medical system, Japan) which can acquire 128 spice images with one spin and CT Mx-8000 (Phillips) which can acquire 4 slices. Scanning conditions were 120 kV, 10.9 seconds, and 140 kV, 26 seconds, respectively. The CT equipment used in head scanning was CT SOMATOM Definition AS (Siemens, Germany) CT scanner.

To measure exposure dose of the subject, this study used the human body phantom for the whole body (Model PBU-31, Kyoto Kagaku, Japan) and glass dosimeter Dose Ace (Model GD-352M).

Table 3. Comparison of the 4 and 128 MDCT with Image Quality Scores.

MMotality	IImage Quality	SSD	*P*-value
44-MDCT	30.50	00.25	< 0.05
1128-MDCT	40.43	00.15	< 0.05
MMB-CT	40.21	00.15	< 0.05

In abdominal MDCT scanning, absorbed doses measured with glass dosimeter were 35.8 ± 0.46 mGy by 4-MDCT, and 19.03 ± 0.25 mGy by 128-MDCT, showing that radiation doses needed for acquiring meaningful images are smaller for 128-MDCT. In skull CT scanning, the doses measured with glass dosimeter were 21.4 ± 0.43 mGy by 4-MDCT; 13.7 ± 0.43 mGy by 128-MDCT; 5.02 ± 0.19 mGy by Mobile CT, which means that with the development of technology, doses have decreased ($P < 0.05$). In wrist bone scanning, dose was 3.42 ± 0.17 mGy by Mobile CT, identifying that by using Mobile CT, we need smaller dose in getting images effective in diagnosis (Table 2).

3.2. Mobile CT image evaluation results

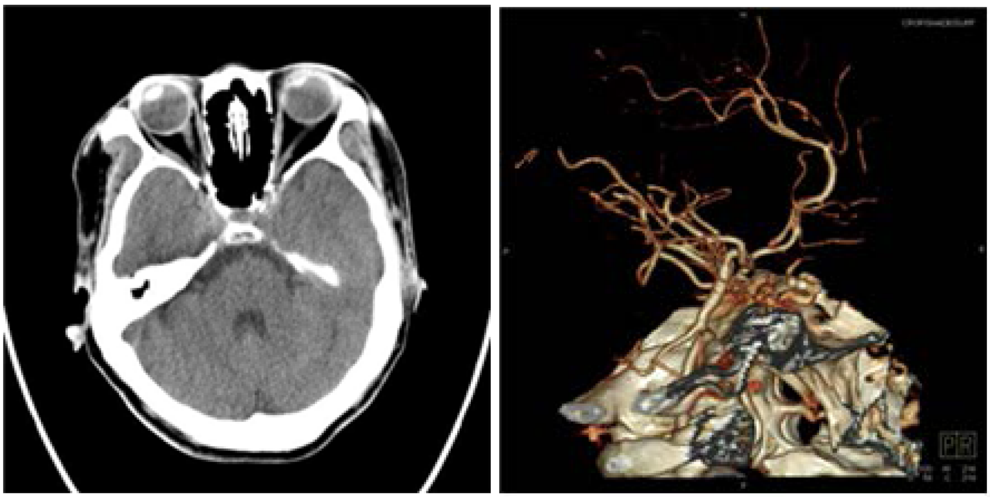
In skull CT scanning, the images acquired from MDCT and Mobile CT were graded on the 5-point Likert scale: 4-MDCT images got 3.50 point; 128-MDCT images got 4.43 point; Mobile CT images got 4.21 point. The 128-MDCT got the highest point, followed by 4-MDCT and Mobile CT. The difference was statistically significant ($P < 0.05$). (Table 3, Fig. 3, 4, 5). Such findings show that Mobile CT allows us to get proper, effective images for diagnosis while reducing exposure doses.

Low radiation doses has potential to harm patients. There is no threshold for radiation safety, which means that there is no safe dose. Thus, it is very important to reduce doses. For this reason, it is necessary to do researches on DLP dose, absorptive dose, and effective dose generated by CT scanning, and it is urgent to develop a standardized protocol designating dose limits per device.

Fig. 3. (Color online) 2D images acquired from Mobile CT scanner (a) brain, (b) wrist.

(a) (b)

Fig. 4. (Color online) 3D images acquired from Mobile CT scanner (a) facial bone, (b) wrist.



(a) (b)

Fig. 5. (Color online) 2D, 3D images acquired from Mobile CT scanner (a) 2D brain, (b) 3D Angiography.

Table 4. Comparison of literature reports and present study for dose with abdominal CT scans.

Study	Study Examination	Scaning Protocol	ESD (mGy)
Japan	head	Computed Tomography	65
GSF	head	Computed Tomography	60 (CTDIw)
IAEA BSS No. 115	head	Computed Tomography	50
Present study	facial	Mobile Computed Tomography	5.02
	hand	Mobile Computed Tomography	3.42

4. Conclusions

In skull CT scanning, exposure doses measured with glass dosimeter were as follows: 21.4 ± 0.43 mGy by 4-MDCT; 13.7 ± 0.43 mGy by 128-MDCT; 5.02 ± 0.19 by Mobile CT, which shows that Mobile CT requires relatively lower dose to get meaningful images in diagnosis ($P < 0.05$). In skull CT scanning, the images acquired from MDCT and Mobile CT were graded on the 5-point Likert scale: 4-MDCT images got 3.50 point; 128-MDCT images got 4.43 point; Mobile CT images got 4.21 point. The 128-MDCT got the highest point, followed by 4-MDCT and Mobile CT. The difference was statistically significant ($P < 0.05$). The above findings show that Mobile CT is good for getting high-quality image and reducing radiation exposure doses. It is expected that more hospitals use Mobile CT.

Acknowledgment

This research was supported by a Gimcheon University research grants in 2019.

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