

Measurement of computed tomography dose profile with pitch variation using Gafchromic XR-QA2 and thermoluminescence dosimeter (TLD)

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Abstract. This research was aimed to check the patterns of dose profile on adult and pediatric head scan. We compared measurement result on dose profile along the z- axis rotation at peripheries and center phantom with a variety of pitch, i.e. 0.75, 1, 1.5 for adult and pediatric head protocol, keeping the rest of the scan parameters constant. Measurements were performed on homogeneous, cylindrical PMMA phantom with diameters of 16 and 10 cm using XR-QA2 Gafchromic film and TLD as dosimeters. The measurement result indicated a decrease in the dose about 50% and 47% for adult and pediatric head scan with the increase of pitch. For 0.75 value of pitch adult head scan, dose range for each position were (2.4 – 5.0) cGy, (3.1 – 5.3) cGy, (2.2 – 4.5) cGy, (2.8 – 5.3) cGy, and (3.3 – 5.6) cGy for position of center, 3, 6, 9 and 12 o'clock peripheral phantom position respectively. Dose profile for adult and pediatric head scan protocols has pattern curve with the maximum dose in the middle and tendency of symmetry near the edges, with different the plateau length along z- axis direction in accordance to the measurement position in the phantom.

1. Introduction

CT-scan is an important part in diagnostic radiology. CT-scan is used in a variety of clinical applications, for example, intra-cranial examination in neurology, diagnostics in oncology, staging and treatment planning in radiotherapy. In addition, CT-scan is also used for cardiology, angiography, virtual endoscopy and as image-guidance in interventional procedures [1].

CT-scan can perform three dimension image, but it gives the patient dose 10-50 times more than the radiation of conventional X-ray [2]. Optimization of radiation protection and safety is important in order to get the low dose for patient but diagnostic purpose can be still achieved. The importance of information dose received by patients, measurements were taken directly along z-axis rotation of the scan, so we can know how the actual dose profile. Dose profile along z-axis rotation of the scan can be measured using TLD and film. Related research dose profile has not been done. Measurement of dose profile required dosimeter which can measure radiation dose along z-axis rotation of the scan. In 2011 Mourão, Gonçalves and Alonso have done dose profile measurements on the CT-scan. They used Toshiba Aquilion CT-scan and protocol PMMA head phantom with 16 cm in diameter and 15 cm in length. Measurements using Strip Gafchromic-XR film. Research results for all variations of pitch 0.8, 1 and 1.5 higher doses obtained on all edges than dose in center phantom position. For a



tube voltage of 120 kV dose values obtained at the edge of 31% greater than the dose in the phantom center [3].

The difference with previous research, to get the profile dose more accurate in this study performed by variation dosimeter using Gafchromic XR-QA2 film and rod TLD, than using polymethyl methacrylate (PMMA) cylinder 16 cm in diameter which represents the adult head and 10 cm represents the pediatric head. Profile doses of both phantom and dosimeters will be analyzed. Dose profile obtained results are expected to complete the dose received information useful for patient and clinic.

2. Methodology

Dose profile measurement using film gafchromic performed on two variations of PMMA phantom, both 16 cm in diameter for adult head and 10 cm in diameter for pediatric head, variations of pitch 0.75; 1 and 1.5, as well as variations in the position of the phantom center, with four position clockwise: 3, 6, 9 and 12 o'clock position were shown in figure 1. The Gafchromic film placed crosswise in the middle of the shell phantom was shown in figure 2. After exposure to radiation is read using a scanner Gafchromic. The film was scanned using EPSON V700 scanner and then was evaluated using ImageJ software.

For the calibration process, annealing TLD advance in Medical Physics Laboratorium Universitas Indonesia with a temperature 400° C for one hour followed by oven 100° C for three hours. Than, TLD exposed to dose of 6 cGy, 120 kV x-ray BATAN. Radiation processes carried out by the SSD 100 cm in the air. After exposure, the TLD was saved approximately 1x24 hours to avoid instability in TLD readings. TLD was read using a Harshaw TLD reader. The readings obtained value in μC units, then TLD sorted from smallest to largest value reading. TLD grouped into three groups and each group has one calibration factor value. TLD dose profile measurement only performed at the center position for measurement adult head phantom with 0.75 and 1 pitch value was given in figure 3.

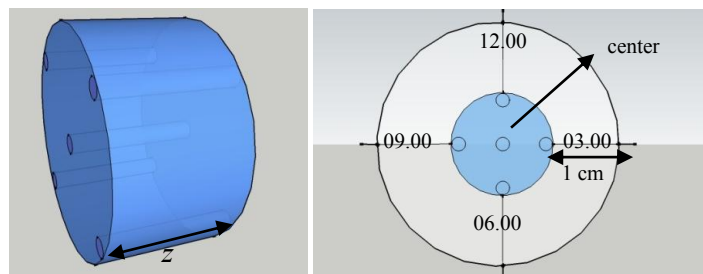


Figure 1. PMMA phantom.

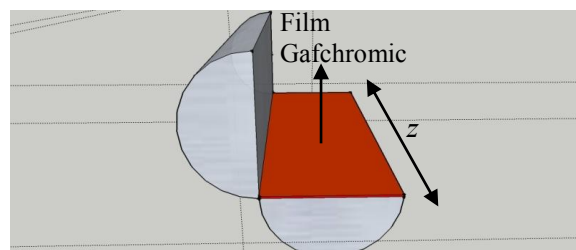


Figure 2. Position of Gafchromic film in holder at PMMA phantom.

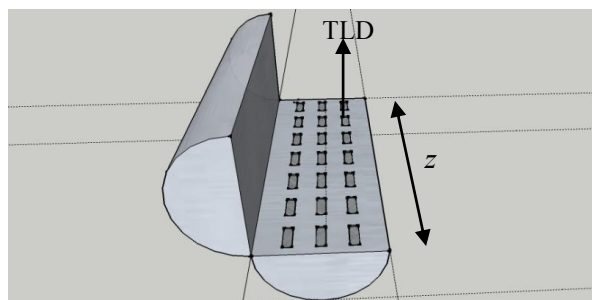


Figure 3. Position of TLD in holder at PMMA phantom.

3. Results and discussion

Dose obtained from TLD measurement values tended to be discrete, having a distribution and dose values being almost the same with measurement results in XR-QA2 Gafchromic film. A similar pattern was observed between pediatric and adult head scan protocols, with the maximum dose in the middle and tendency of symmetry near the edges was shown in figure 4.

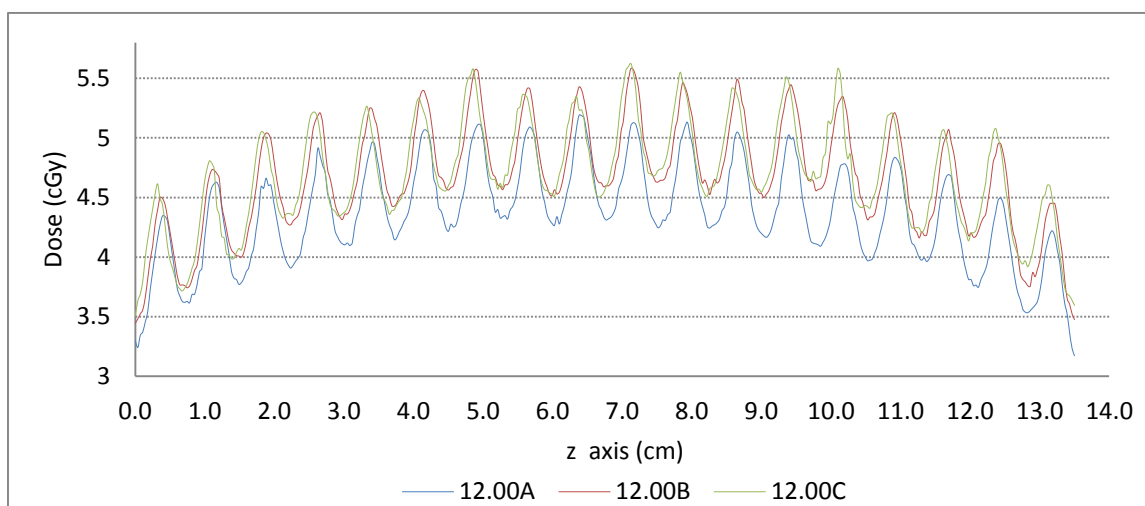


Figure 4. Three times the measurement results adult head phantom dose profile at 12.00 position, pitch value 0.75 used Gafchromic film.

Table 1. Dose profile at z-axis (cGy) in adult head phantom.

Pitch	Measurement	Position	Center	03.00	06.00	09.00	12.00
0.75	Dose (cGy)	Left	2.4	3.1	2.7	2.8	3.3
		Right	2.4	3.0	2.2	3.0	3.2
		Peak	5.0	5.3	4.5	5.3	5.6
1	Dose (cGy)	Left	1.3	2.2	1.4	2.1	2.1
		Right	1.5	2.2	1.5	2.2	2.2
		Peak	3.8	3.9	3.3	3.7	3.7
1.5	Dose (cGy)	Left	1.1	1.1	1.1	1.2	1.2
		Right	1.2	1.1	1.0	1.0	1.2
		Peak	2.6	2.9	2.4	2.8	3.0

Table 2. Dose profile at z-axis (cGy) in pediatric head phantom.

Pitch	Measurement	Position	Center	03.00	06.00	09.00	12.00
0.75	Dose (cGy)	Left	1.6	2.0	2.0	1.9	2.3
		Right	1.6	2.0	1.8	2.0	2.2
		Peak	3.3	3.6	3.2	3.5	3.8
1	Dose (cGy)	Left	1.1	1.2	1.2	1.4	1.3
		Right	1.2	1.5	1.2	1.4	1.6
		Peak	2.8	2.8	2.6	2.8	3.0
1.5	Dose (cGy)	Left	0.9	0.9	0.8	0.8	0.9
		Right	0.9	0.9	0.9	0.9	0.9
		Peak	1.7	1.7	1.5	1.7	1.8

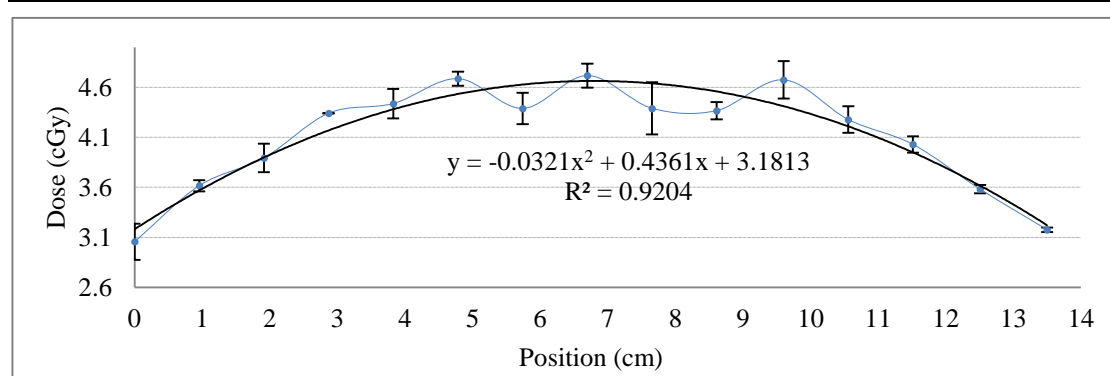


Figure 5. Dose profile of TLD at center adult head phantom with 0.75 pitch using TLD.

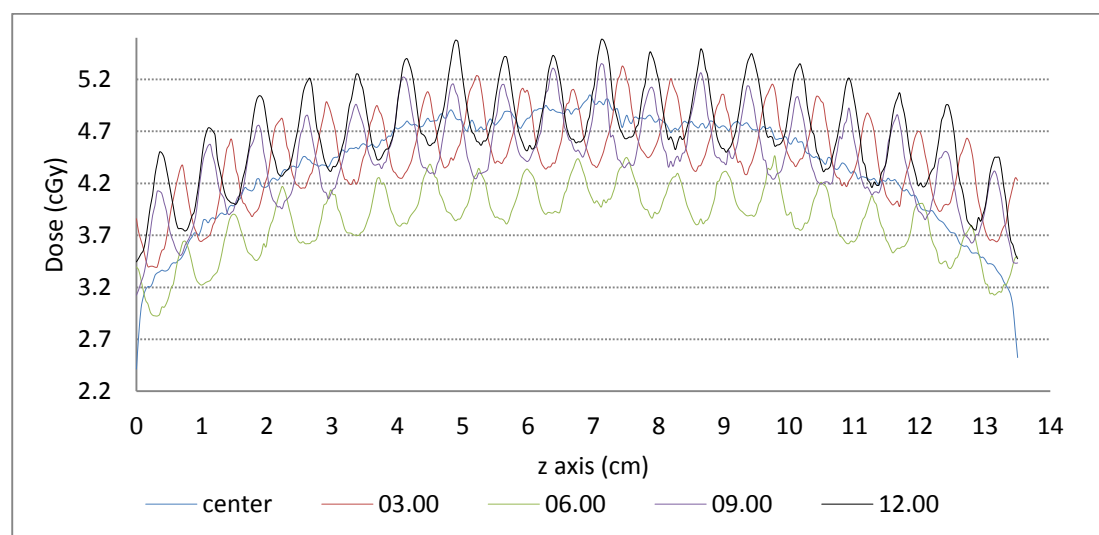


Figure 6. Dose profile of adult head phantom with 0.75 pitch using Gafchromic film.

For the adult head scan, dose range for each pitch values were (2.4-5.0) cGy, (1.3-3.8) cGy and (1.1-2.6) cGy for pitch values of 0.75, 1 and 1.5 respectively. For the pediatric head scan, dose were in the ranges of (1.6-3.3) cGy, (1.1-2.8) cGy and (0.9-1.7) cGy for the pitch values of 0.75, 1 and 1.5, respectively. A radiation dose of the scan was found proportional to the pitch value. For 0.75 value of pitch adult head scan, dose range for each position were (2.4 – 5.0) cGy, (3.1 – 5.3) cGy, (2.2 – 4.5) cGy, (2.8 – 5.3) cGy, and (3.3 – 5.6) cGy for position of center, 3, 6, 9 and 12 o'clock peripheral phantom position respectively. While, for 0.75 value of pitch pediatric head scan. The dose was in the

ranges of (1.6 – 3.3) cGy, (2.0 – 3.6) cGy, (1.8 – 3.2) cGy, (1.9 – 3.5) cGy, and (2.2 – 3.8) cGy for position of center, 3, 6, 9 and 12 o'clock peripheral phantom position respectively. Radiation dose of the scan was found to be maximum at the 12 o'clock position and minimum at 6 o'clock position.

4. Conclusion

The measurement results indicated a decrease in the dose about 50% and 47% for adult and pediatric head scan with the increase of pitch. A radiation dose of the scan was found to be maximum at the 12 o'clock position and minimum at 6 o'clock position. For each position different length of the plateau was found due to the different amount of scattered radiation received. Dose profile for adult and pediatric head scan protocols has pattern curve with the maximum dose in the middle and tendency of symmetry near the edges with different plateau length along z- axis direction in accordance to the measurement position in the phantom.

References

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