Estimation of Half-Value Layer for Dual-Energy Computed Tomography Acquisition Using a New Copper Absorption Method

Kosuke Matsubara[1)], Wataru Mitsui[2)], Hiroji Iida[2)], Naoya Mizukami[3)], China Matsumoto[3)], Kichiro Koshida[1)], Osamu Matsui[4)]

1) Department of Quantum Medical Technology, Faculty of Health Sciences, Kanazawa University, Kanazawa, Japan
2) Department of Radiological Technology, Kanazawa University Hospital, Kanazawa, Japan
3) Department of Radiological Technology, School of Health Sciences, Kanazawa University, Kanazawa, Japan
4) Department of Radiology, Faculty of Medicine, Kanazawa University, Kanazawa, Japan

E-mail: matsuk@mhs.mp.kanazawa-u.ac.jp

1. Introduction

- ✓ Materials can be separated or quantified by dual-energy computed tomography (DECT). Of late, DECT is often used in clinical situations, and dual-source CT (DSCT) is used to execute DECT acquisition.
- ✓ When DECT acquisition is executed by DSCT, one X-ray tube outputs X-rays with relatively low tube voltage (100 or 80 kVp), another tube outputs X-rays with relatively high tube voltage (140 kVp with a tin [Sn] filter [Sn/140 kVp]), and the two tubes simultaneously output X-rays when rotated.
- ✓ In DECT, it is difficult to obtain half-value layer (HVL), which is generally used to calculate a patient's absorbed dose, by the conventional aluminum or copper absorption method because of the technical limitation.

2. Objectives

- ✓ This study aimed to estimate HVLs for DECT acquisitions by a new copper absorption method.

3. Materials

- ✓ A 128-section DSCT (SOMATOM Definition Flash; Siemens Healthcare, Erlangen, Germany) was used in this study (Fig.1).

Fig.1: A 128-section DSCT

- ✓ Exposure dose was measured while executing single-energy CT (SECT) acquisition with 120 kVp and DECT acquisitions with combinations of 100 and Sn/140 kVp and 80 and Sn/140 kVp after inserting a thimble-type ionization chamber (10x5-6; Radcal, Monrovia, CA) into each 0.04–0.6-mm-thick cylindrical copper filter (99.9% pure) and placing them into the center of CT gantry (Figs.2, 3).

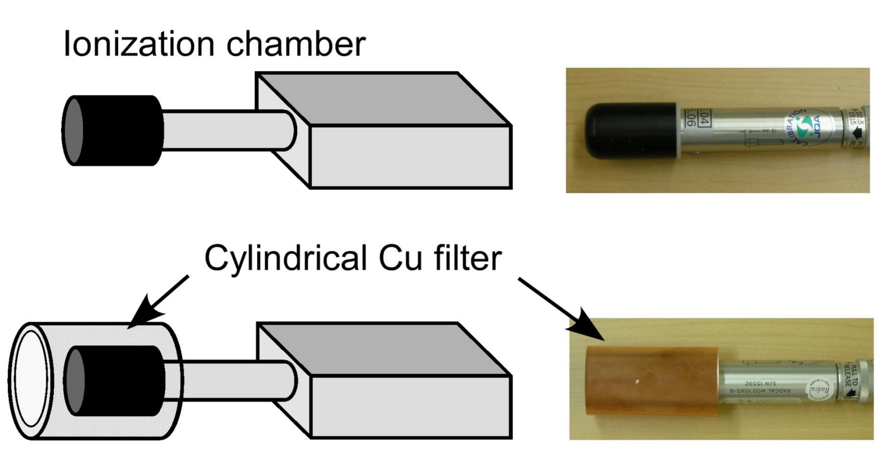


Fig.2: Ionization chamber and cylindrical copper filter

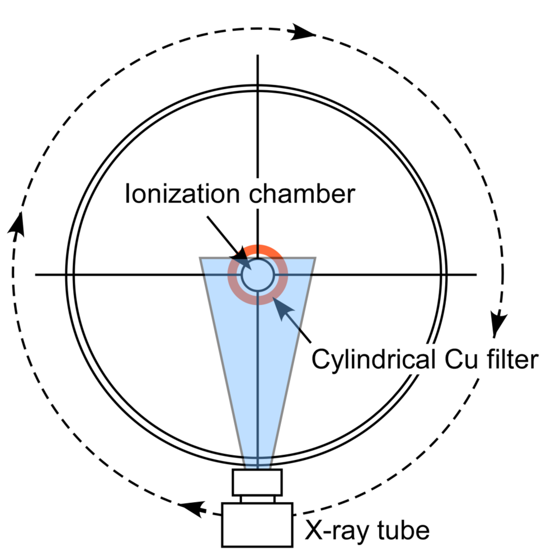


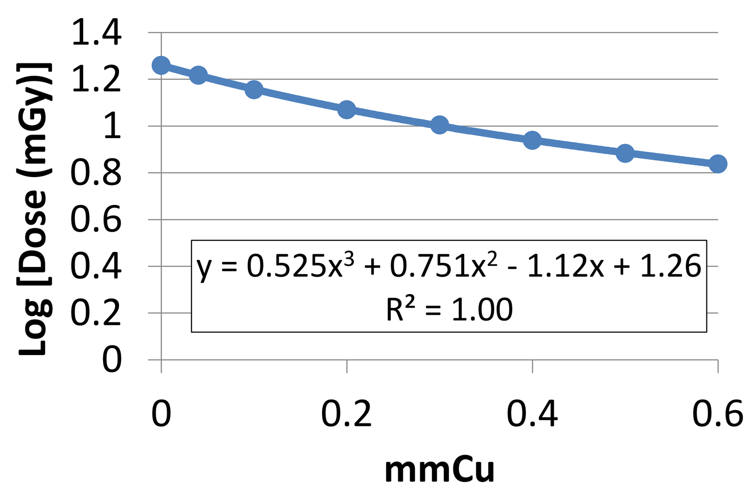
Fig.3: Geometrical setup of chamber and filter

- ✓ Acquisition parameters while executing SECT or DECT acquisitions were as follows: 100-mA tube current, 1.0-s rotation time, and 32×1.2-mm (SECT) or 32×0.6-mm (DECT) slice collimation.
- ✓ The thickness of the copper filter, which reduces the intensity of radiation by half (first HVL), was then calculated in each acquisition.
- ✓ The first HVLs were revised by excluding the contribution of all scattered radiation using the correction equation (y=1.066x [x, measured first HVL; y, corrected first HVL]) shown in our previous study.[1)]
- ✓ The first HVL for SECT with 120 kVp was estimated using the conventional copper absorption method.[2)]

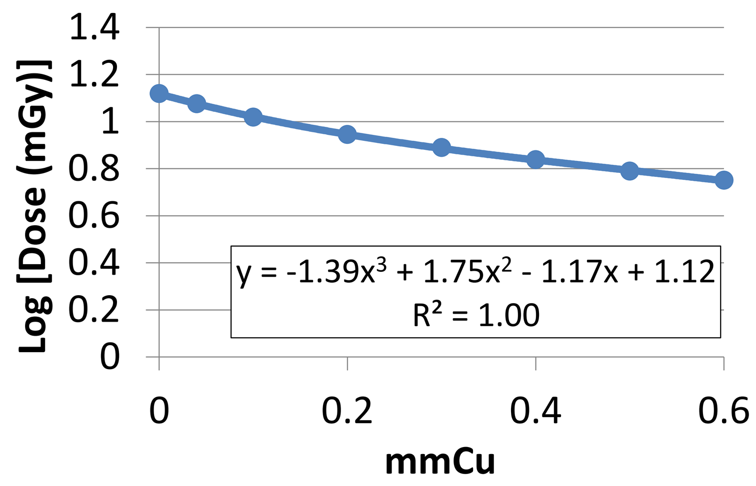
4. Results

- ✓ The expose doses with 0-mm-thick copper filter were calculated by extrapolating from other exposure doses. Corrected first HVLs were calculated as shown in Fig.4.

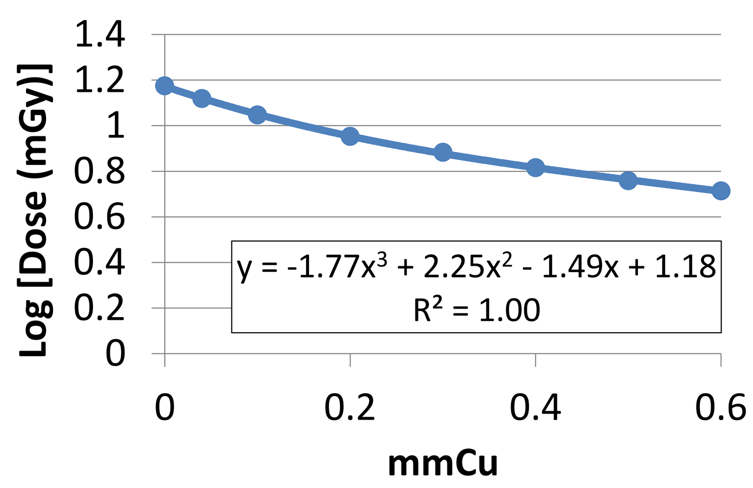
☐ 120 kVp



☐ 100 and Sn/140 kVp



☐ 80 and Sn/140 kVp



$$\log\left(\frac{I_{fHVL}}{I_0}\right) = \log\left(\frac{1}{2}\right)$$

$$\log I_{fHVL} = \log I_0 - \log 2$$

- I_0: exposure dose with 0-mm-thick copper filter
- I_{fHVL}: exposure dose with copper filter equivalent to first HVL

Fig.4: Measurement and calculation of first HVLs

- ✓ The results of measured and corrected first HVLs and calculated effective energies are shown in Table 1.

Table 1: The results of first HVLs and effective energies

Tube voltage (kVp)	Measured first HVL (mmCu)	Corrected first HVL (mmCu)	Effective energy (keV)
120	0.425	0.453	58.5
100 and Sn/140	0.462	0.493	60.3
80 and Sn/140	0.315	0.336	52.4

- ✓ The first HVL and the calculated effective energy for SECT acquisition with 120 kVp in the conventional copper absorption method were 0.455 mm and 58.6 keV, respectively.

5. Discussion

- ✓ The first HVL for SECT acquisition with 120 kVp observed in the new copper absorption method was almost similar to that observed in the conventional copper absorption method.
- ✓ Although correction of all scattered radiation is mandatory, one can obtain HVLs easily and accurately by the new copper absorption method.

6. Conclusions

- ✓ The HVLs for DECT acquisitions by DSCT can be successfully estimated using the new copper absorption method.

References

1) Iida H, Noto K, Mitsui W, et al. A new method of measuring effective energy using copper-pipe absorbers in X-ray CT. Nippon Hoshasen Gijutsu Gakkai zasshi 2011;67(9):1183-91.
2) Ogama N. The Measurement of Effective Energy in the Diagnostic X-ray. Nihon Hoshasen Gijutsu Gakkai Zasshi 2001;57(5):550-6.