

Effective Dose Display System in Gastric Cancer X-ray Screening

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Abstract

Purpose: The purpose of this study is to build a system for effective dose display immediately after the gastric cancer X-ray screening. **Materials and Methods:** The regression equation of effective dose and dose area product (DAP) was introduced from the data of 500 persons including DAP and effective dose calculated using program for X-ray Monte Carlo. **Results:** The effective dose was 5.39 mSv of median, 1.18 mSv of minimum, and 38.38 mSv of maximum. The regression equation was $Y=0.354+0.0003772X$ (Y: effective dose, mSv, X: DAP, mGy cm²). Using the regression equation, the effective dose can be estimated from DAP and displayed just after the individual screening. **Conclusions:** "Effective dose display system" was constructed to display effective dose immediately after gastric cancer X-ray screening. This system is on the way to be reformed by improving the regression equation on larger data.

Keywords: Dose area product, effective dose, entrance surface dose, gastric cancer X-ray screening, standard radiography

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INTRODUCTION

On the mortality of cancer, the first place is lung cancer, the second place is colorectal cancer, and the third place is gastric cancer in Japan.^[1] The guideline of the Japanese Society of Gastroenterological Cancer Screening (revised edition 2011) recommends population-based screening (Standard radiography I) of 8 images and opportunistic screening (Standard radiography II) of 16 images.^[2] High concentrated barium sulfate (>200 w/v%) is recommended as the contrast media in addition to 5.0 g of foaming agent.

The availability of gastric cancer X-ray screening has been reported in some papers,^[3,4] but any disadvantages such as wrong aspiration of barium sulfate^[5] and exposure of X-ray radiation^[6,7] are increasing in recent years. There are several reports on the effective dose in gastric cancer X-ray screening until now.^[6-10] The report of Maruyama^[6] showed collective effective dose equivalent for 4000 persons and estimated 0.57 mSv of effective dose equivalent with 7 million number of domestic diagnoses in 1991. However, the gastric cancer X-ray screening in 1991 was not Standard radiography. The report^[8] showed 3.39 mSv of effective dose by film method using

high-density barium sulfate and 3.44 mSv of that by film method using moderate-density barium sulfate. Furthermore, another report^[10] showed the values by digital radiography (DR), namely 4.41 mSv by Standard radiography I and 5.15 mSv by Standard radiography II. These values of effective dose were estimated using the standard computer phantom of adult men and women. The calculation of effective dose by the conventional method takes some time, and the value cannot be displayed just after the screening examination. It is only effective dose (mSv) and dose area product (DAP) (mGy cm²) now to display a value.

The aim of this study is to devise the method getting an effective dose display immediately after the gastric cancer X-ray screening. In this study, the regression equation is prepared on the data of (DAP, cGy cm²) and effective dose obtained by the conventional method. Using the equation, the effective dose can be estimated from measured DAP at once.

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MATERIALS AND METHODS

The protocol for this study was approved by the Ethical Committee of the Osaka Center for Cancer and Cardiovascular Disease Prevention. This study was partly supported by a KAKENHI Grant-in-Aid from the Ministry of Education, Culture, Sports, Science, and Technology (Scientific Research (C) No. 15K08764).

Subjects and methods of X-ray screening

The numbers of the subjects are shown in Table 1. In the Osaka Center for Cancer and Cardiovascular Disease Prevention (the Center), the subjects were examined in January 1–November 30, 2013, using Standard radiography I in population-based screening ($n = 120$) or using Standard radiography II in opportunistic screening ($n = 120$). The device used in the center was I. I. DR digital X-rays television (TV) fluorography device SREX-D32C Aitella (TOSHIBA Medical Co., Ltd. Tokyo, Japan). The kV and s values were varied and averaged, whereas the mA value was fixed. The average values were 82 kV, 100 mA, and 28 ms. The average value of 82 kV was for 240 people. The beam angulations/projections were not fixed, and the beam angulations/projections changed during gastric cancer X-ray screening. These angulations/projections were averaged in each institution. The center had an average 20 cm + 20 cm of beam angle formation/projection.

In hospital A, the subjects ($n = 190$) were examined in October 1–December 25, 2014, using original radiography (24 images) in opportunistic screening. The device used in hospital A was flat panel detector (FPD) digital X-rays TV fluorography device ZEXIRA DREX–ZX80 (TOSHIBA Medical Co., Ltd. Tokyo, Japan). The kV and s values were varied and averaged, while the mA value was fixed. The average values were 94 kV, 200 mA, and 17.9 ms. The average value of 94 kV was for 190 people. The beam angulations/projections were not fixed,

and the beam angulations/projections changed during gastric cancer X-ray screening. Hospital A had an average 23 cm + 23 cm of beam angle formation/projection.

In hospital B, the subjects ($n = 70$) were examined in October 1–February 28, 2015, using original radiography (27 images) in opportunistic screening. The device used in hospital B was FPD digital X-rays TV fluorography device SONIAL VISION Safire 17 (Shimadzu Co., Ltd. Kyoto, Japan). Hospital B had an automatic approach with regard to kV, mA, and s values. The average values were 90 kV, 310 mA, and 42.5 ms. The average value of 90 kV was for 70 people. The beam angulations/projections were not fixed, and the beam angulations/projections changed during gastric cancer X-ray screening. Hospital B had on average 18 cm + 24 cm of beam angle formation/projection.

Table 2 shows the values on X-ray spectrum of TV fluorography device in three facilities. (DAP, cGy cm²) and entrance surface dose (ESD, mGy, value of the error of measurement 0.1%) of one examination were measured by the area dosimeter of DIAMENTOR M4-KDK (PTW-Freiburg Co. Ltd., Germany).

Regression equation for effective dose and effective dose display system

From the value of DAP, the effective dose was calculated using program for X-ray Monte Carlo (PCXMC) dose calculation ver 2.0.1.3 (STUK-Radiation and Nuclear Safety, Helsinki, Finland) (PCXMC) following the conventional method on the standard computer phantom.

The 163.0 cm and 63.0 kg are the number of screenees in gastric cancer screening. The maximum energy (keV) was 150 keV, and the number of photons was 20000. A scatter diagram was generated for dose-area product (DAP) and the effective dose, and regression analysis was performed on the data to derive the predictive equation (regression equation) for 500 screening events.

Specification changes for Digital Imaging and Communications in Medicine (DICOM) gateway for X-ray TV devices.

DIAMENTOR DICOM MPPS IF is software that adds area dosage and incident dose obtained from DIAMENTOR MA-KDK to data of completed testing sent by PDR-03A via DICOM MPPS, and transmits this to RIS.

Table 1: The subjects for gastric cancer X-ray screening

	Male	Female	Total
The Center	120	120	240
Hospital A	110	80	190
Hospital B	48	22	70
Total	277	222	500

The Center: Osaka Center for Cancer and Cardiovascular Disease Prevention

Table 2: The calculation of X-ray spectrum

	Total filtration	X-ray (kv)	X-ray tube anode angle	Beam width beam height (cm)	Image width Image height (cm)
The Center	Al 3.6 mm	82	12.5	15.56×15.56	20×20
Hospital A	Al 1.5mm + Ta 0.015 mm	94	12.5	17.89×17.89	23×23
Hospital B	Al 1.1 mm + Cu 0.1 mm	90	12	14.00×18.67	18×24
	Height: 163.0 cm weight: 63.0 kg		FID: 110 cm FSD: 85.58 cm		

The Center: Osaka Center for Cancer and Cardiovascular Disease Prevention

FID	Focal Image receptor Distance
FSD	Focal Surface Distance

Additionally, it sets the patient ID, received in inter-process communications from the software on the same PC before starting the testing, to the data after completing testing.

During MPPS, a hospital-designated formula ($Y = 0.354 + 0.0003772X$) was applied to recalculate the value recorded by an area dosimeter and stored in the tag (0118, 115E), although currently this is performed using a dosimeter.

The system to display effective dose immediately after the end of screening was constructed on a program to calculate effective dose using the regression equation. This system was called “effective dose display system”. The block diagram of this system is shown in Figure 1.

Statistical analyses

All statistical analyses were performed using PASW Statistics 18 for Windows (IBM SPSS Japan Inc., Tokyo, Japan).

RESULTS

Regression equation of dose-area product and effective dose

Table 3 shows the median values of DAP and effective dose based on the subjects of three facilities. The scatter diagram of every DAP and effective dose is shown in Figure 2. The equation obtained by regression analysis is as follows and is also written in Figure 2.

$Y=0.354+0.0003772X$ Y: effective dose (mSv) X: DAP (mGycm²)

0.354: constant 0.0003772: coefficient

$R^2 = 0.996 (P < 0.05)$

Table 3: Median values of dose area product and effective dose			
Hospital	Gastric cancer X-ray screening	DAP (mGycm ²)	Effective dose (mSv)
The Center	Population-based screening	8,763.60	3.36
	Opportunistic screening	10,348.15	4.27
Hospital A	Opportunistic screening	24,038.00	9.3
Hospital B	Opportunistic screening	17,590.00	6.75
	Median value	13,969.08	5.51
The Center: The Center: Osaka Center for Cancer and Cardiovascular Disease Prevention			
DAP: Dose area product			

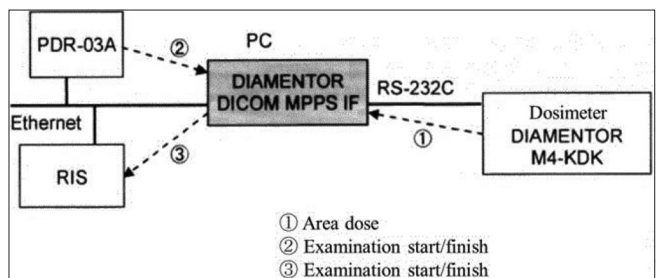


Figure 1: Block diagram of effective dose display system

Effective dose display system

The program enrolled of the regression equation was constructed as calculated effective dose was displayed on screen immediately after screening examination. In the Center, usually DAP, ESD and effective dose of the screening have been displayed on LCD screen after the end of the screening.

For example.

Make DAP the effective dose.

$DAP (mGycm^2)=12086.8mGycm^2$

$Y mSv = 0.354+0.0003772X mGycm^2$

$0.0003772 \times 12086.8 mGycm^2 + 0.354 = 4.91314096 mSv$

Immediately after the examination, the effective dose is obtained and displayed on the computer screen. An indication screen of the system is shown in Figure 3.

DISCUSSION

Since the accident of the nuclear power generation in Fukushima prefecture Japanese people often ask question using effective dose (mSv), the unit of radiation dose. In the center, DAP and ESD are calculated and displayed on PC-LCD screen at the end of the screening examination. However, effective dose has not been displayed as mentioned in the introduction. On the effective dose in gastric cancer X-ray screening, the authors reported in served papers.^[8-10] The values of effective dose in them were calculated using PCXMC software and could not be displayed just after the screening examination. In this study, “effective dose display system” was constructed to display effective dose immediately after gastric cancer screening.

Effective dose is important for a protective unit in X-ray examination. The evaluation of effective dose has been performed using the adult computer phantom of standard men and women according to international commission on radiological protection

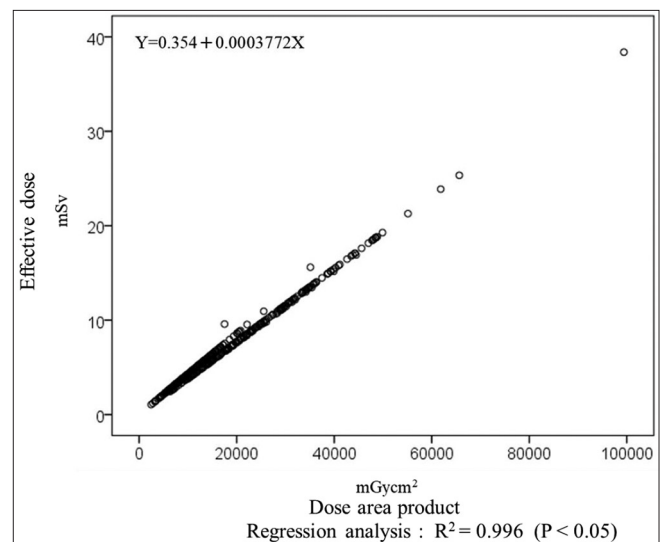


Figure 2: Scatter diagram of dose area product and effective dose

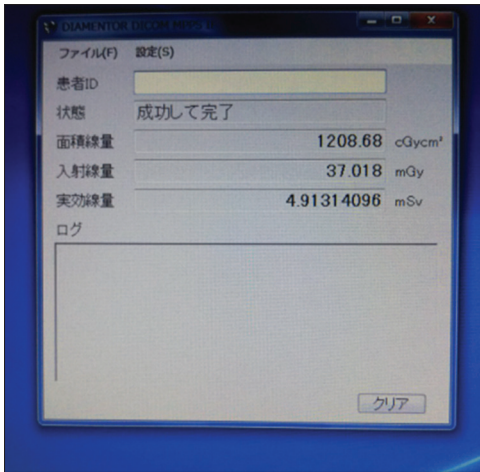


Figure 3: Screen shot of gastric cancer X-ray screening effective dose display system

advice Publication103 year 2007. The value of effective dose is an indicator of radiation on a reference man or woman and not the indicator of actual personal radiation. The risk assessment of radiation for cancer must not be done using effective dose.

As shown in this study, the effective dose can be displayed on PC and informed in response to individual demand. This may relieve the subjects to worry about X-ray dose. However, it is considered to be important that effective dose is explained very carefully, keeping in mind of effective dose on reference person. Until now, similar values of effective dose have been obtained according to the regression equation of this study and the conventional method using PCXMC on standard computer phantom. We work in “effective dose display system.”

The predictive precision of the equation in this study is high in $R^2 = 0.996$. At present, DAP data from many institutions are collected to improve a precision in the regression equation. In near future, effective dose will be calculated using the regression equation on larger data and displayed immediately after gastric cancer X-ray screening.

CONCLUSIONS

The regression equation of DAP and effective dose was introduced on the data of 500 subjects. “effective dose display

system” was constructed to display effective dose immediately after gastric cancer X-ray screening.

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Conflicts of interest

There are no conflicts of interest.

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