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Effects of an Imaging Table on the Distribution of Scattered Radiation

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ABSTRACT

Effects of an imaging table on the distribution of scattered radiation were studied using a wooden imaging table of 70cm in height. At the height of above 80cm, doses were increased by using the imaging table. On the other hand, at below 70cm, doses were decreased because of the shielding effect of the imaging table. The maximum increment of dose was 92.6% at 170cm, while the maximum decrement of dose was 49% at 30cm and 40cm. Dose distribution depended markedly on the direction at below 70cm, while slightly at above 80cm. Effects of the imaging table on the distribution of scattered radiation was apparent at the exposure condition which induced more dose.

KEY WORDS

Scattered radiation, X-ray tube, Radiation exposure, Imaging table

INTRODUCTION

Various modalities using X-ray system have been widely used in the diagnosis of diseases. However, they have also showed some disadvantages, such as harmful radiation exposure to the patients and technologists. Concern has already existed about the reduction of this harmful radiation exposure. Although some researches about the efforts to reduce patient exposure were reported[1)-2)], the distribution of scattered radiation generated from an X-ray tube has not been described. It is well known that scattered radiation degrades the imaging quality and increases the patient exposure. Therefore, it is important to make efforts to reduce it as low as possible, although the occurrence of scattered radiation is inevitable during the using of X-ray. In the previous report, we described about the relation between exposure condition and scattered radiation[3)]. Scattered radiation increased exponentially with the increase of tube voltage and radiation field size, while it increased linearly with the increase of tube current and exposure time. The maximum dose was shown at 50 to 100cm vertically from the ground. Marked reduction of dose with the increase of distance from an X-ray tube was also revealed.

In this paper, we will describe the effects of an imaging table on the distribution of scattered radiation.

MATERIALS AND METHODS

1. MATERIALS

1) X-ray tube

An X-ray tube with a rotating tungsten target (CIRCLEX 1/2 U10CN-25, Shimazu Corp., Kyoto) was employed. In this apparatus, target angle at the anode was 18 degrees and the maximum heatstorage capacity was 80 KHU. During this study, the X-ray tube was always fixed at a constant location in an imaging room, whose size was 550cm×510cm×340cm (Fig. 1). The center of the X-ray tube located at 184cm from the nearest

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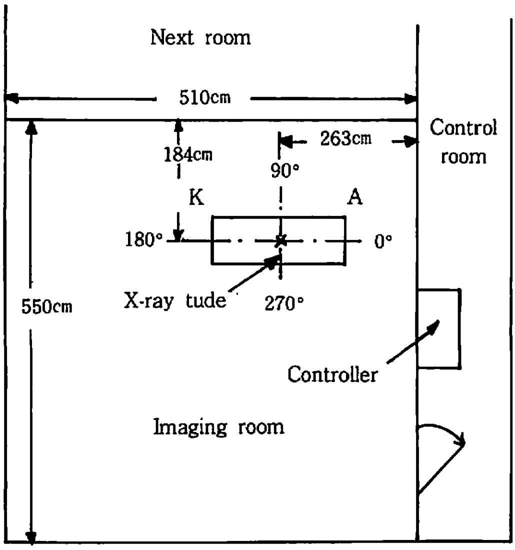

Fig. I Location of an X-ray tube in the imaging room.

The anode (A) and the cathode (K) of the X-ray tube are shown.

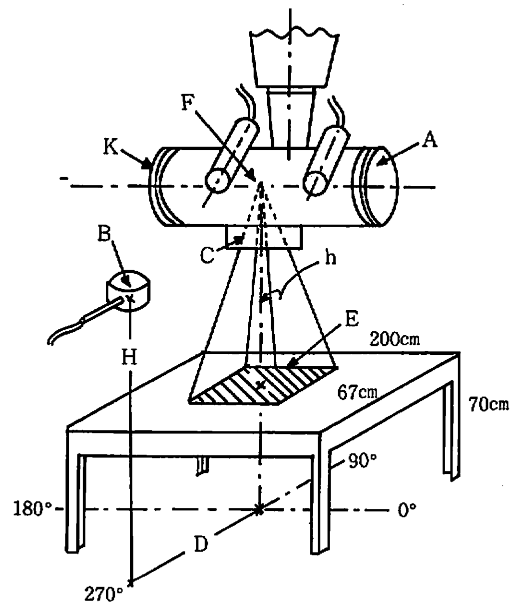

Fig. 2 Schematic illustration of an X-ray a tube and imaging table

A ; Anode, K ; Cathode, B ; Detector, C ; Collimator, F ; Focus, E ; Field size,
D ; Horizontal focus-to-detector distance (100cm)
H : Detector-to-ground distance (cm)
h : Focus-to-table distance (100cm)

wall, at 263cm from the other wall, and at 170cm vertically from the ground. The axis of the X-ray tube was always kept parallel to the nearest wall (Fig. 1).

2) Imaging Table

A wooden imaging table with a dimension of 200cm×67cm×70cm was used (Fig. 2). The imaging table was installed in a way that the center of it was always consistent with that of the X-ray tube. The distance (h) from the focus (F) to the surface of the imaging table was 100cm (Fig. 2).

3) Detector

An ionization-chamber detector (Model 660, Victoreen Corp., USA) was used. The vertical detector-to-ground distance (H) could be changed from 13cm to 170cm. The horizontal focus-to-detector distance (D) was kept at 100cm (Fig. 2).

2. METHODS

Dose around the X-ray tube was measured circumferentially at a 30degree's interval and plotted on the polar coordinate, where the anode (A) and the cathode (K) were set as 0° and 180°, respectively (Fig. 1). As the collimator (C) attached beneath the X-ray tube was fully opened, the field size (E) was rectangularly 44cm×44cm on the imaging table, or 75cm×75cm on the ground (Fig. 2).

The result of three measurements taken at the same condition was showed as mean (M.) and standard deviation (S.D.) .

1) Evaluation of the reproducibility of measurement

In order to evaluate the reproducibility of measurement, five groups of experiments with the imaging table were repeated at the same condition (80kVp-100mA-0.1sec, D, H and h ; 100cm) on different days. The coefficient of variation (C.V.), a parameter showing the reproducibility, was calculated by dividing standard deviation by mean ; (C.V.)=(S.D.)/(M.).

2) Dose distribution at different condition

In order to evaluate the effects of dose amount, doses with or without the imaging table were measured at three kinds of exposure conditions ; 100KVp-100mA-0.2sec., 80KVp-100mA-0.05sec. and 80KVp-100mA-0.2sec. In the first exposure condition, it induced more occurrence of dose than

Table I Measurements of five groups at the same condition on different days ; 80kVp-100mA-0.1sec, D,H, and h ; 100cm.

(A) mean (M., μR), standard deviation (S.D.), and coefficient of variation (C.V.) of doses measured at the constant angle.

Angle	M.(μR)	S.D.	C.V.
0°	105	7.7	0.07
30°	106	8.6	0.08
60°	101	8.4	0.08
90°	123	9.2	0.07
120°	118	10.2	0.09
150°	112	9.0	0.08
180°	115	16.2	0.14
210°	113	12.3	0.11
240°	116	14.8	0.13
270°	112	11.6	0.10
300°	109	11.0	0.10
330°	108	8.0	0.07

(B)M. (μR), S.D., and C.V. of doses measured circumferentially from 0° to 330° at a 30° interval.

Group	M.(μR)	S.D.	C.V.
A	110	9.0	0.08
B	106	5.3	0.05
C	117	8.4	0.07
D	99	4.9	0.05
E	124	13.9	0.11

the other two conditions.

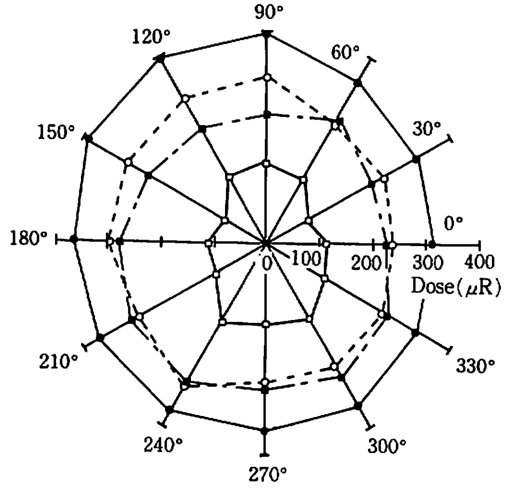

Fig. 3 Dose distribution at 100KVp-100mA-0.2sec
● ; 100cm of H with the imaging table,
○ ; 100cm of H without the imaging table,
□ ; 30cm of H with the imaging table,
■ ; 30cm of H without the imaging table,

3) Comparison of doses with or without the imaging table

Doses with or without the imaging table were compared at the condition of 100KVp-100mA-0.2sec.

RESULTS

1 . Evaluation of the reproducibility of measurements

The doses measured in five groups on different days are expressed as M. (μR)±S.D. ; C.V. and shown in Table 1(A). Significant differences of doses among different angles were not revealed, although doses at 90° and 120° were slightly more than that at other angles. Because the values of C.V. were so small, it could be said that the reproducibility of measurements was excellent. Table 1(B) shows the M. (μR), S.D., and C.V. of doses measured circumferentially from 0° to 330° at a 30° interval. Similarly, there was no significant difference among the five groups. In addition, small C.V. suggested dose distribution was isotropic.

2 . Dose distribution at different condition

Fig. 3 shows dose distribution at 30cm and 100cm of H with or without the imaging table at 100kVp-100mA-0.2sec. Except dose at 30cm with the imaging table, significant differences among any other directions were not found. However, dose at 30cm with the imaging table depended markedly on the direction. Doses at 90° and 270° were more than those at 0° and 180°. Significant differences between with or without the imaging table were shown. At 100cm of H, the dose with the imaging table was more than that without the imaging table, while the former was less than the latter at 30cm of H.

Fig. 4 shows dose distribution at 80KVp-100mA-0.05sec, and 80KVp-100mA-0.2sec. These doses are prominently less than those at 100KVp-100mA-0.2sec. Furthermore, doses at 90° and 270° are more than those at 0° and 180°. Dose distribution apparently depends on the direction.

3. Comparison of doses with or without the imaging table.

Without the imaging table, the maximum dose of 320 μR was shown at 70cm of H (Fig. 5). However, with the imaging table, the maximum dose of 360 μR was shown at 100cm of H. At above 80cm, doses with the imaging table were more than those without the imaging table. The maximum increment of 92.6% was shown at 170cm. At below 70cm, doses with the imaging table were less than those without the imaging table. The maximum decrement of 49% was shown at 30 and 40cm.

DISCUSSION

Scattered radiation not only degrades the imaging quality but also increases the harmful radiation exposure. Therefore, it is preferable to reduce scattered radiation. In the previous paper, we described the effects of exposure condition on scattered radiation[3]. In this paper, we studied the effects of an imaging table on the distribution of scattered radiation. By using the 70cm high imaging table, dose distribution could be divided into two parts. One is above the imaging table and the other is below the imaging table. When the detector-to-ground distance (H) increased to a height above 80cm, doses were increased accordingly by using the imaging table. However, when this distance was below 70cm, doses were decreased. After being generated at the X-ray tube, X-ray runs toward

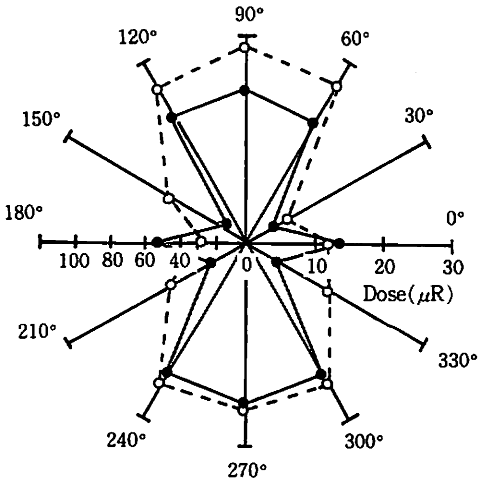

Fig. 4 Dose distribution with the imaging table at different condition. ● ; 80KVp-100mA-0.05sec, 30cm of H. O ; 80KVp-100mA-0.2sec, 60cm of H. Opened (O) and closed circles (●) are illustrated on different scales, with 20 interval (20, 40, 60, 80, and 100) and 10 interval (10, 20, and 30), respectively.

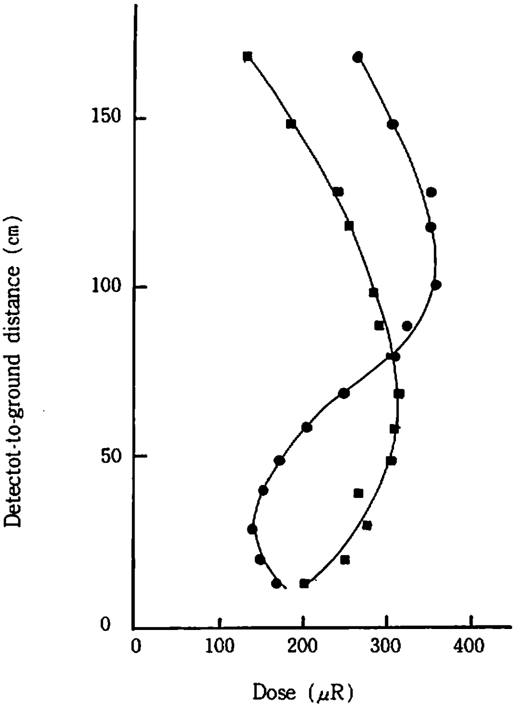

Fig. 5 The relation between detector-to-ground distance and dose at 100KVp-100mA-0.2sec. ■ ; without the imaging table, ● ; with the imaging table. At above 80cm, doses with the imaging table are more than those without the imaging table, while at below 70cm, doses with the imaging table are less than those without the imaging table.

a film through a collimator. When there exists anything on the way of passage which reflects the X-ray beam, scattered radiation occurs. Although it was once suggested that scattered radiation was caused uniformly around the X-ray tube, actually it was not quite uniform. At below 70cm, doses at 0° and 180° were less than that of the others. The directions of 0° and 180° correspond to the long axis of both X-ray tube and imaging table. Therefore, doses at 0° and 180° were decreased because of the shielding effect of the imaging table. In this study, a wooden imaging table was used. If an imaging table of different material was used, different effects might be shown because of the different attenuation coefficient of material.

In spite of the recommendation of the international Commission on Radiation Units and Measurements (ICRU), SI units were not employed because the detector used in this study only gave the mR units instead of SI units. Conversion of the survey meter reading to SI units was not conventionally accomplished.

Radiological technologists can't escape from radiation exposure as far as they are working in the imaging room with X-ray generator system. However, they can reduce it. Therefore, they should consider the protection of themselves from radiation exposure when they manage the X-ray apparatus. It is very important to know the distribution of scattered radiation from an X-ray apparatus in one's institutes.

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散乱線の分布に及ぼす撮影台の影響

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要　　旨

X線撮影時に発生する散乱線は画質を低下させると同時に，被検者や技師の被曝を増加させるので少ない方が好ましい。管電圧や管電流，照射時間等の撮影条件が散乱線の発生に及ぼす影響については先に報告した。今回は散乱線の空間分布に及ぼす撮影台の影響について検討した。撮影台として高さ 70cm の木製撮影台を用いた。100KVp－100mA－0.2sec の場合，散乱線は 80cm 以上の空間では撮影台のないときに比べて増加し，170cm の高さで最大 92.6 %増加した。一方，70cm 以下では散乱線は撮影台のないときに比べて減少し，30cm および 40cm の高さで最大49%減少した。80cm 以上では方向依存性は少なかったが，70cm 以下では撮影台の影響を受けて方向により値は著明に変化した。以上，撮影台は散乱線の空間分布に影響し，特にX線量の発生が多い撮影条件で著明に認められた。