KFKI-74-57

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CALCULATIONS ON THE DOSE DECREASING AND IMAGE QUALITY IMPROVING EFFECTS OF AN ABDOMEN DODGER

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BUDAPEST

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ABSTRACT

Monte Carlo calculations are performed to study the effects of an abdomen dodger. For this study the inhomogeneous Snyder phantom is assumed to be irradiated by an X-ray tube operated at 80 kVp. By the use of a dodger which compensates the varying thickness of the body the exposure distribution on the photoreceptor can be made more uniform and the absorbed dose decreases.

АННОТАЦИЯ

Из-за неравномерной толщины человеческого тела на краях рентгеновского снимка желудка очернение больше, чем в середине. Для компенсации этого применяются т.н. доджеры. Методом Монте-Карло было рассчитано влияние доджера, используемого на практике, на улучшение снимка и уменьшение дозы. Исследуемое лицо было моделировано неоднородным фантомом Снайдера при напряжении рентгеновской трубки 80 кв.

KIVONAT

Az emberi test nem-egyenletes vastagsága miatt a gyomorröntgen felvételeken a kép szélein nagyobb a feketedés, mint középen. Ennek kompenzálására szokás az u.n. dodger-eket használni. Egy gyakorlatban is használt dodger képjavító és dóziscsökkentő hatását számoltuk Monte Carlo módszerrel. A vizsgált személyt az inhomogén Snyder fantommal modelleztük, a röntgencső feszültségét 80 kV-nak választottuk.

Introduction

The cross section of a patient's trunk is ellipse-like. Performing an X-ray examination, those photons that enter the body in the middle of the trunk have to pass through a much thicker layer than those that arrive at the thinner parts i.e. at the patient's periphery. As a consequence of this varying thickness the edge of the film is often overexposed.

This effect can be decreased by placing a dodging filter between the X-ray source and the patient. Moreover the use of a dodger decreases the dose absorbed in the patient.

A general description of the dodging technique was given by Edholm and Jacobson (1) while Monte Carlo calculations for the analysis of the effects caused by a skull dodger were performed by Kusoffsky, Carlsson and Edholm (2) In this paper an abdomen dodger is considered by a Monte Carlo computer program.

The model

The patient is modelled by the inhomogeneous Snyder phantom (3) . This phantom has a total volume of about 70 liter and is divided into three main parts; head, trunk and legs. The trunk, which is irradiated in our case, is an elliptical cylinder. The inhomogeneous phantom comprises

23 organs, the lungs and the skeleton have elemental compositions and densities differing from the remaining tissues.

The X-ray source is placed at 100 cm from the photoreceptor (fig. 1) in front of the patient and is assumed to have an emission spectrum of a tube operated at 80 kVp with 2 mm Al filtration (4) .

The dodger is placed at 30 cm from the source, its profile is chosen such that by projecting on the patient it exactly fits to the profile of the trunk. The dodger consists of 97.5 wt% Al, 0.8 % Mg, 0.7 % Mn and 1.1 % Si, with a density of 2.8 g/cm^3. A similar device is manufactured at Saab-Scania, Linköping, Sweden, but we fitted the geometry to our phantom. (5)

If the (x,y) plane of a coordinate system is fitted to the plane that separates the trunk from the legs and the axis z is directed toward the head then the trunk is irradiated from z = 15 to z = 45 cm. Some of the phantom's organs e.g. the stomach, the liver, the kidneys and the small intestine lay within this region. The beam width is x = 40 cm. This measure is valid on the receptor plane therefore the incident area on the patient's body is less.

To analyse the distribution of the exposure on the photoreceptor, the receptor areas are divided into 9 zones. Each zone consists of two strips: left and right from the middle. The strips are parallel to the axis z.

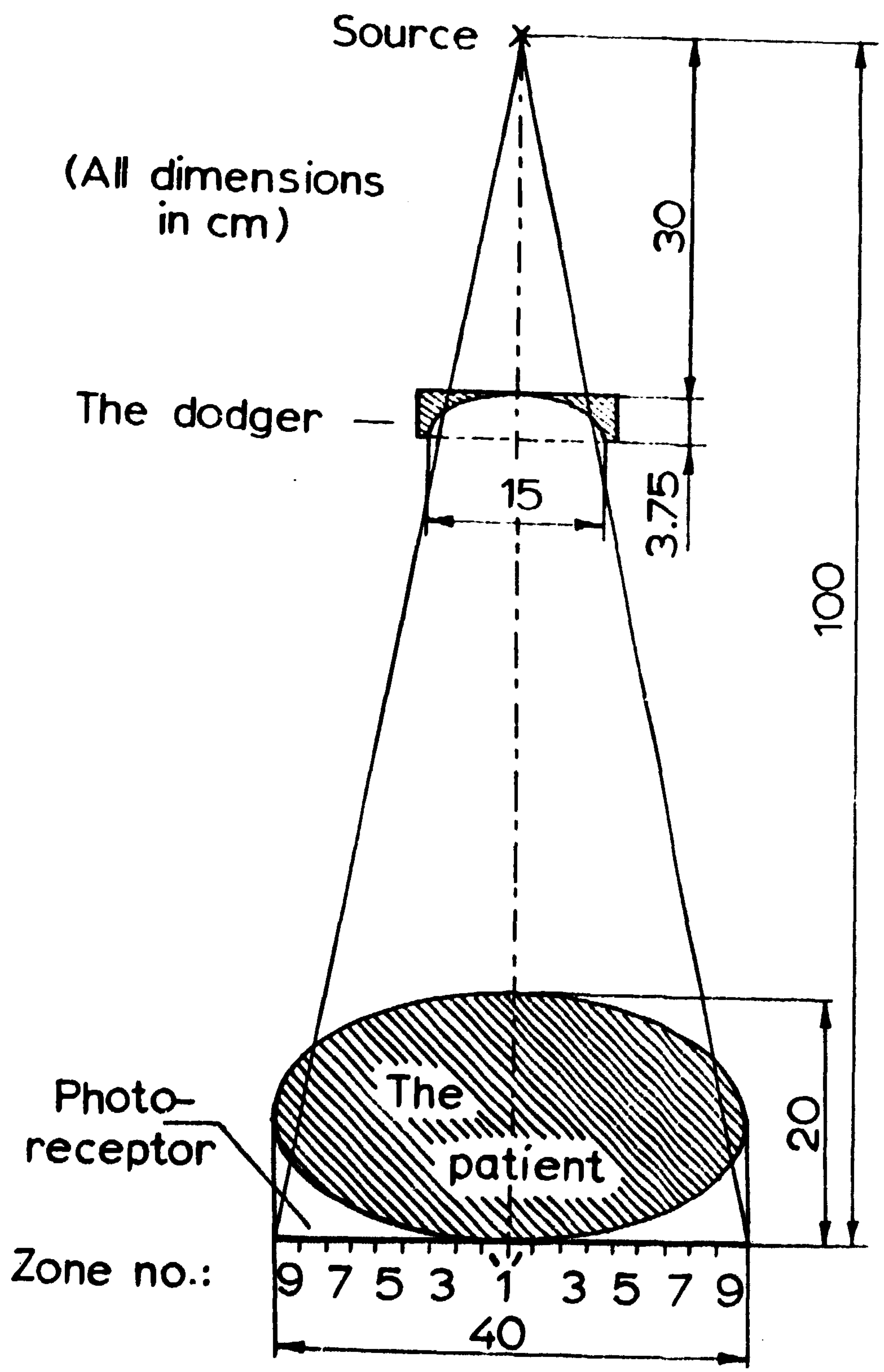

Fig. 1 Irradiation and detection circumstances

Results

Both the doses absorbed in some organs and the exposures on the zones of the receptor are calculated by a modified version of the Monte Carlo program DISDOS (6, 7).

The exposure distributions are presented in figs 2 and 3. The exposure values are normalized to one primary photon (i.e. to one photon emitted into the irradiation solid angle). The ratio of the highest and lowest exposures on the different zones (fig. 2) decreases to about 1.7 by the use of the dodger from 3.8 achieved without dodger.

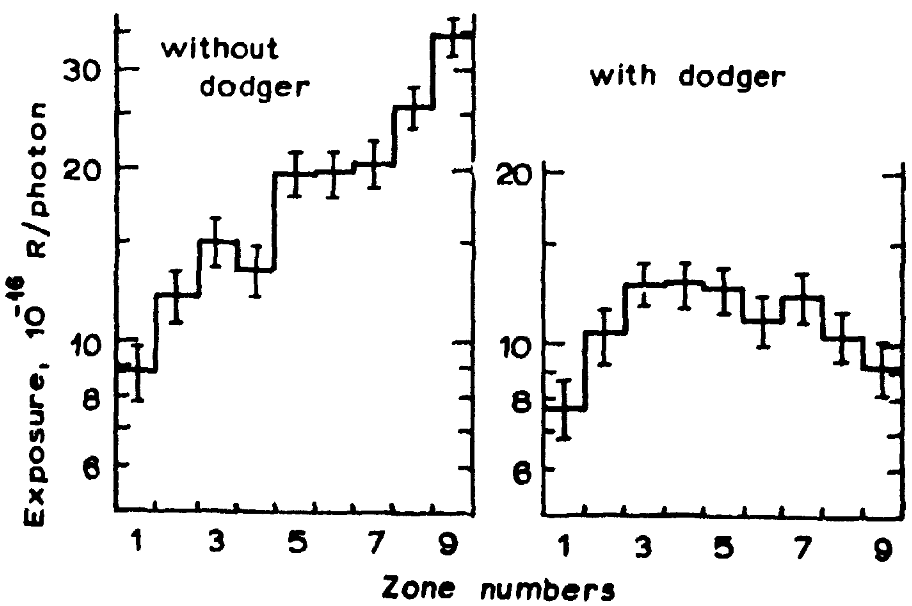

Fig. 2 The exposure on the photoreceptor. The exposure values are normalized to one primary photon. To indicate the statistical uncertainty the standard deviations are marked.

Besides the uniformity the image quality can be characterized by the ratio of the exposures due to the scattered and uncollided photons as the scattered photons do not carry useful information.

This ratio increased from 0.18 to 0.21 for the three central strips when the dodger is used. Similar increase in the outer strips was not found. Here the radiation scattered from the dodger compensates the decrease of the radiation scattered inside the body.

The doses absorbed in some organs are summarized in Table 1.

If we assume that the presence of the dodger practically does not influence the exposure in the middle of the photoreceptor the same number of emitted photons can be used when the examination is carried out with and without dodger, therefore the dose/primary photon values can be compared directly. By this assumption the doses absorbed in the different organs or parts of the body are less by about 20-40 % when the dodger is used.

Here it must be noted that the equality of the doses on the middle of the receptor is not confirmed in Fig. 2, where a decrease due to the dodger can be estimated to about 10 percent. An even higher decrease was found in praxis (P. Edholm, Linköping University, private communication). This means that the incident exposure has to be increased, therefore the dose decreasing effect is not so strong as it can be seen from Table 1.

Table 1 The doses absorbed in some organs and in the total body, in rad/10^{14} photon. To characterize the statistical uncertainty the coefficients of variation are given in parentheses.

Organs	Dose without dodger: D_1	Dose with dodger: D_2	Dose reduction D_2/D_1
stomach	3.78 (4.3 %)	2.50 (4.4 %)	0.66
small intestine	2.42 (4.5 %)	1.93 (2.3 %)	0.80
large intestine	4.84 (5.2 %)	3.52 (3.2 %)	0.73
averaged for the G-I tract	2.67 (4.2 %)	2.03 (4.4 %)	0.76
skeleton	0.358 (2.1 %)	0.230 (3.4 %)	0.64
bone marrow	0.385 (2.1 %)	0.256 (3.4 %)	0.66
liver	2.66 (4.6 %)	1.63 (2.1 %)	0.61
kidneys	0.684 (41.2 %)	0.497 (43.2 %)	0.73
spleen	1.06 (3.6 %)	0.593 (8.5 %)	0.56
averaged for the total body	0.645 (0.3 %)	0.396 (0.6 %)	0.62

Comments

As different patients have different dimensions, the dodgers do not fit exactly to the bodies' contours the irradiation circumstances may be very different from these; therefore the results presented here cannot be applied for any given abdomen examination but can be used as average values, characteristic for an average examination, thus applicable in the estimations for the total population.

The author acknowledges to Prof. P. Edholm and Dr. L. Kusoffsky (Linköping University, Linköping, Sweden) for their valuable comments and discussions which supported greatly this study.

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Kiadja a Központi Fizikai Kutató Intézet
Felelős kiadó: Szabó Ferenc igazgatóhelyettes
Szakmai lektor: Makra Zsigmond, Andrási Andor
Nyelvi lektor: Makra Zsigmond
Példányszám: 255 Törzsszám: 74-10.129
Készült a KFKI sokszorosító üzemében
Budapest, 1974. julius hó