

Estimation of surface dose (skin absorbed dose) for the patient undergoing standards radiologic examinations

تخمين جرعة السطح (جرعة الجلد) للمرضى الذين يقومون بإجراء فحوصات شعاعية اعتيادية

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Abstract:

Estimate surface dose (skin absorbed dose) for the patient who are examined by the X-ray (conventional X-ray) relative to different X-ray examination of the different parts of the body ,also to investigate the methodology used in the determination of the surface absorbed dose in diagnostic radiology. In kV X-rays for low-energy photons (tube potential up to 150 kV).The main parameters that which involved in this projects are ,tube potential(KVp),tube current and the time of exposure (mAs) .Different radiographic examination were enrolled in this project corresponding to different radiographic techniques (KVp & mAs) .Mathematical calculations were done to calculate the surface dose for the patient from the X-ray .The results show that the surface dose (skin dose) was differ from one radiographic examination to another depending on the radiographic technique that which applied .Mean surface dose were found to be within the established international reference doses. The results are useful to be used as a baseline upon which future dose measurements may be compared.

الخلاصة :

الغرض من هذا البحث هو لتخمين جرعة السطح (جرعة الجلد الممتصة) للمرضى الذين يقومون بإجراء فحوصات شعاعية بالأشعة السينية (الاعتيادية) نسبة إلى الفحوصات المختلفة لأعضاء الجسم ،وكذلك لتحديد الطريقة المناسبة لتخمين جرعة السطح في حقل الأشعة التشخيصية التي تكون فيها طاقة الأشعة السينية واطئة بحدود (١٥٠) كيلو فولت .المعلومات المعتمدة في هذا البحث هي فولتية انبوبة الأشعة السينية ،التيار الكهربائي لأنبوبة الأشعة و زمن التعرض الإشعاعي .مختلف الفحوصات الإشعاعية تم إدراجها في هذا البحث مشيرة إلى اختلاف العوامل التقنية للفحص من فولتية وتيار إضافة إلى زمن التعرض. عمليات رياضية تم إجرائها لحساب جرعة السطح (جرعة الجلد) للمرضى من الأشعة السينية. النتائج أوضحت أن جرعة الجلد تختلف من فحص شعاعي إلى آخر معتمدة على عوامل التصوير الإشعاعي التقنية التي يتم تنظيمها لإجراء الفحص. وجد إن متوسط جرعة السطح من ضمن الجرعة المثبتة دولياً . النتائج مفيدة لأن تكون مصدر لمقارنة قياسات الجرعة مستقبلياً .

Introduction :

Radiation exposures from diagnostic medical examinations are generally low and are almost always justified by the benefits of accurate diagnosis of possible disease conditions. There is no direct evidence of radiation ever causing any harm at the exposure levels encountered with diagnostic radiological examinations[1] Millions of radiologic procedures are performed on patients across the nation each year. A wide range of radiation absorbed doses is delivered to patients by the various diagnostic imaging modalities that use ionizing radiation. Even though these procedures are assumed to produce a net benefit, the potential for radiation-induced injuries to the patient exists. Understanding the typical absorbed doses and the factors that affect them therefore becomes very important[2].X-ray diagnostics is a significant source of radiation exposure among the population. Therefore, it is important that X-ray examinations are conducted using techniques that keep the patients' exposure as low as compatible with the medical purposes of the examinations [3].A surface absorbed dose (skin absorbed dose) of X-ray is the dose absorbed at the surface of the skin where X-ray beam enters. An X-ray beam enters the body from the direction of X-ray tube .A small share of the beam exists from the body on the opposite side ,where it exposure the film or the image receiver.The share of the beam which never exist from the body is absorbed as extra energy by the body internal organs and bones .[4] During recent years, patient dose has become a major issue and because of the increasing awareness and greater realization of the effects of ionizing radiation, X-

ray users are now more demanding of dose information and dose reduction[5] The" European Guidelines on Quality Criteria for Diagnostic Radiographic Images" document defines the diagnostic requirements for normal, basic radiographs, specifying anatomical image criteria and important image details; it indicates criteria for the radiation dose to the patient and gives examples for good radiographic technique by which the diagnostic requirements and dose criteria can be achieved[6] Minimization of skin absorbed dose is best accomplished by making all possible efforts to reduce radiation dose in general while maintaining adequate image quality for diagnosis and intervention. Dose reduction requires attention to several basic principles : (a) control of examination time, (b) control of the number of images obtained, and (c) control of technical factors that affect dose.[7,8]

Diagnostic radiography.

Diagnostic radiography typically refers to any of the means used to create a planar image through the use of x rays. In specific terms, surface dose in diagnostic radiography is proportional to the tube current, the length of exposure, and the square of peak kilovoltage. The roles of these and other factors are discussed within the context of specific modalities. A fourth factor that applies to all of the modalities is called the inverse square law. The inverse square law states that when all other factors are held constant, the dose at any location is inversely proportional to the square of the distance to the source. In other words, if the distance between the source and the location of interest is doubled, the dose will be reduced by a factor of four.[9] Dose to specific organs may vary substantially with the projection used, such as anteroposterior, posteroanterior, and lateral. Organ absorbed dose may be estimated by using a conversion factor along with a measured value of entrance exposure[10].

Method of calculation

*Surface dose (Skin absorbed dose) can be calculated in accuracy of (95%) by the following equation[11] :

$$(\mu\text{Gy}) = \frac{836 \times (\text{KVp})^{1.74} \times (\text{mAs})}{(D)^2} \times \left(\frac{1}{T} + 0.114\right) \text{Skin absorbed dose}$$

where :

μGy : is unit of radiation absorbed dose(1Gy =100 rad).

T: is the total filtration(filter thickness) in units of (mm)which is constant for each X-ray tube type(2.5mm).

D: is the distance between the X-ray tube and patient's skin surface (cm).

*(KVp): refer to the X-ray tube voltage in unit of kilovolt(kv)which is regulated by the radiographer through regulator in X-ray machine.

*(mAs): refer to the product of the electrical tube current in unit of milli-ampers(mA)multipled by the time of exposure to X-ray in second(s.)also it is regulated by the radiographer through regulator in X-ray machine.

*Radiographic examinations also had been taken from practical work in the X-ray unit in Al-Sadder teaching hospital .

Results :

Table(1)

The results of this project are shown in the following table representing the skin absorbed dose in (mGy) for the patient who are examined by the X-ray for the different radiologic procedures :

NO. case	Type of examination	(KVp) Value (KV)	(mAs) Value milliamp ere.Sec.	Minimum skin dose (mGy)	Maximum skin dose (mGy)	Reference value
1	Hand (PA)	40-45	5	0.2	0.25	٠.٣
٢	Thumb	40-41	3-4	0.12	0.17	—
٣	Wrist(PA)	46	3-5	0.15	0.26	—
٤	Wrist(Lat.)	47	3-5	0.16	0.27	—
٥	Forearm(PA)	50	6-8	0.36	0.48	٠.٥
٦	Forearm(Lat.)	٥٠-٤٠	٦	٠.٢٤	٠.٣٦	—
٧	Axial position	٤٦-٤٠	٥	٠.٢٠	٠.٢٦	—
٨	Humerus(AP)	٥٠	٦	٠.٣٦	—	٠.٦
٩	Shoulder(AP)	50	5-8	٠.٣٠	٠.٤٨	٠.٧
١٠	Shoulder (Lat.)	70-80	40-50	٣.٤	6.8	—

*PA(posterior Anterior): refer to radiographic position in which the front face of part of the body want to be examine by X-ray must attach to X-ray film and the back face of same part must facing X-ray tube.

	Type of examination	(KVp) Value (KV)	(mAs) Value milliampere.Se c	Minimum skin dose (mGy)	Maximum skin dose (mGy)	Reference value
11	Foot(PA)	40-45	3-5	0.20	0.25	٠.٥
١٢	Ankle(PA)	44-46	4-6	0.19	0.31	٠.٤
١٣	Knee joint(AP)	48-50	6-8	0.33	0.48	٠.٨
١٤	Patella	50-56	6-8	٠.٣٦	٠.٥٩	—
١٥	Knee joint Weight bearing	45-50	8-12	0.48	٠.٧٢	—
١٦	Hip joint(PA)	65-70	25-40	2.39	8.48	١
١٧	Leg (AP)	44-50	6-9	٠.٢٩	0.54	٠.٨
١٨	Sacrum(AP)	75-85	80-100	9.83	15.28	٢٠
١٩	Vertebrae C-spine	٧٠-٦٠	20-30	1.66	٢.٢٧	٠.٥
٢٠	Lateral(72") c-spine	70	15-20	0.32	0.43	—
٢١	Thoracic vertebra(AP)	70-75	20-25	2.18	3.07	٥
٢٢	Thoracic vertebra(Lat.)	70-75	40-50	4.36	6.14	—

*AP(Anterior Posterior): refer to radiographic position in which the back face of part of the body want to be examine by X-ray must attach to X-ray film and the front face of same part must facing X-ray tube.

	Type examination of	(KVp) Value (KV)	(mAs) Value milliampere.Sec	Minimum skin dose (mGy)	Maximum skin dose (mGy)	Reference value
٢٣	Lumbar(AP)	70	٥٠	٥.٤٥	—	10
٢٤	Lumbar Cone view	80-100	100-120	13.75	24.33	٣٠

٢٥	Pelvis(AP)	65-70	40-50	٢.٨٣	٥.٤٥	١٠
٢٦	Chest(PA) (72")	65-70	10-15	0.18	٠.٣٢	٠.٤
٢٧	Heart (PA)	65-70	10-15	0.36	٠.٣٢	—
٢٨	Skull(PA)	70-85	25-40	2.72	٦.١١	٥
٢٩	Skull(Lat.)	٧٠	-30٢٥	2.72	3.27	٣
٣٠	Town's view	75-80	30-40	3.68	5.50	—
31	Base of skull	80-90	40	5.50	٦.٧٥	—
٣٢	Sinuses Water's view	70	٣٠	٣.٢٧	—	—
٣٣	Sinuses (Lat.)	٧٠	٢٥	٢.٧٢	—	—

* Lat.(Lateral): refer to radiographic position in which the lateral side of the parts want to be examine by X-ray must attach to X-ray film and other side facing the X-ray tube.

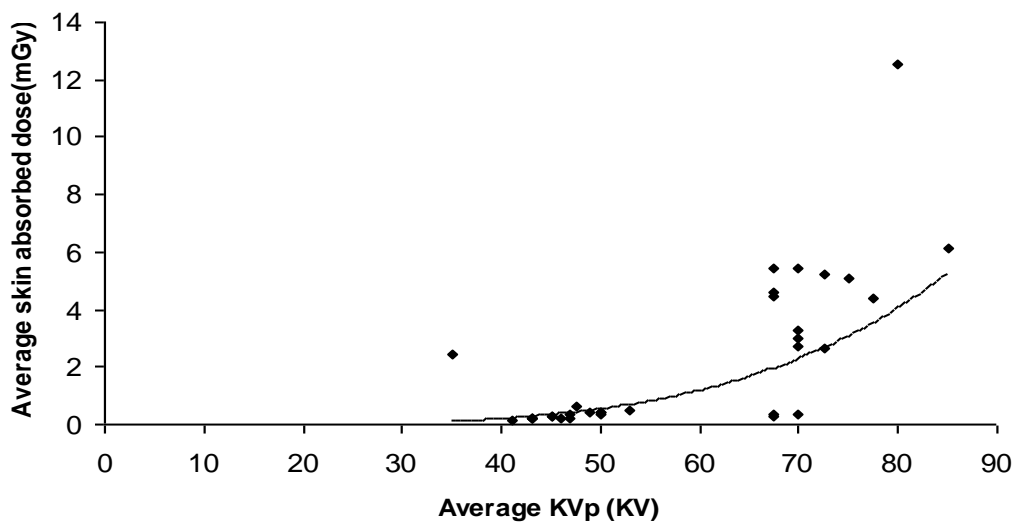
*72": refer to the distance between the focus of the X-ray tube and the X-ray film in inch unit.

Table(2)

Show the average values of both X-ray tube voltage (KVp) , the product of electrical tube current and time of exposure(mAs) and the adjacent values(average) of skin absorbed dose

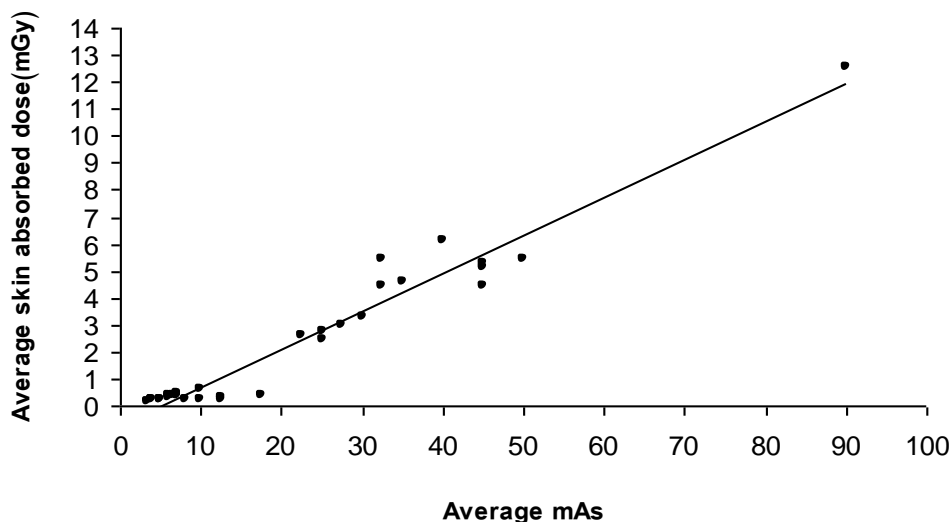
Average KVp(KV)	Average milliampere.Sec mAs	Average skin absorbed dose(mGy)
41.0	3.50	0.145
46.0	4.00	0.205
47.0	4.00	0.215
43.0	5.00	0.225
43.0	5.00	0.230
45.0	6.00	0.300
50.0	6.00	0.360
50.0	6.50	0.390
47.0	7.00	0.370
49.0	7.00	0.405
50.0	7.00	0.420
53.0	7.00	0.475
43.0	8.00	0.225
45.0	10.0	0.250
47.5	10.0	0.600
67.5	12.5	0.250

67.5	12.5	0.340
70.0	17.5	0.375
72.5	22.5	2.625
35.0	25.0	2.465
70.0	25.0	2.720
70.0	27.5	2.995
70.0	30.0	3.270
67.5	32.5	5.435
77.5	32.5	4.415
67.5	35.0	4.590
85.0	40.0	6.125
67.5	45.0	4.460
72.5	45.0	5.250
75.0	45.0	5.100
70.0	50.0	5.450
80.0	90.0	12.55
90.0	110	19.04



Fig(1)

Show the effect of the KVp (KV) of the X-ray tube on the skin absorbed dose(mGy) (exponential relationship).



Fig(2)

Show the effect of mAs (milliampere.Sec.) of the X-ray tube on the skin absorbed dose (Linear relationship).

Discussion.

The method outlined here to conduct surface dose assessment has proved useful in assisting X-ray departments. The results showed a general downward trend in the calculated surface dose with evidence to suggest that this resulted not only through equipment replacement, but also through optimization of exposure factors. The results show that the surface dose is highly dependant on the (KVp)ⁿ and this come in agreement with [11] ,also we found that when (mAs) had increase ,the surface dose increase significantly so we think that's due to increase in the (mAs) leading to increase in the number of unwanted X-ray photon that consequently increase in surface dose . The results clarify that the effects of (KVp) is significantly exponential as what the formula appreciate Fig.(1), and so the (mAs) linearly affecting on the surface absorbed dose of the patient Fig(2). There was broad agreement between results of this work and the results obtained by [12] who are not mentioned to the radiographic technique (KVp and mAs) but mentioned to the radiographic examinations ,but [13] refer to the radiographic techniques and the radiographic examinations as exactly we did in our work. The calculation method employed here showed good agreement with the TLD measurement technique and may produce smaller errors compared with TLDs for comparative assessments.[12] The accuracy of the calculational method is particularly important where it is used to estimate individual patient doses. Other studies for calculation of surface dose for the patient under radiographic procedures had been done using monte carlo program in which the results are in agreement with our results[14]

Conclusions

*The mathematical method has three potential advantages:

- 1.First, it requires minimum additional work by the radiology department since exposure charts should already be in existence for every X-ray unit.
- 2.Second, the mathematical method allows dose studies to be extended to a much larger number of examinations than would be cost effective with other dosimeters.
- 3.Third, it allows assessment of low dose examinations, which may deliver doses below the practical sensitivity of TLDs and some dosimeters.

*The work described here to evaluates the use of mathematical estimates of skin dose from a large number of X-ray examinations

*The highest absorbed dose that which calculated by this project was in the safe side as the dose threshold of 2 Gy for deterministic effects was not reached

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