Mathematical Calculation of Patient's Fluoroscopic Entrance Dose in Extracorporeal Shock Wave Lithotripsy

الحساب الرياضي لجرعة الدخول للمرضى الذين تم فحصهم بجهاز الفلوروسكوبي إثناء عملية تفتيت الحصى بجهاز (الازول)

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Abstract

The aim of this study was to determine the radiation doses to patients during extracorporeal shock wave lithotripsy (ESWL) and compare them with the available bibliographical data. In this method localization of the renal stones is attained by the use of fluoroscopy, and thus ESWL is included among those medical practices associated with patient radiation exposure.
The main parameters that which enrolled in this project are the time of exposure and x-ray techniques (mA and kv). Fifty cases were enrolled in this project. Entrance dose were calculated using mathematical equation that which relate the X-ray techniques (mA and kv)and distance from the patients to entrance dose. The results show that the entrance dose was significantly very high relative to these obtained from normal radiographic examination .

الخلاصة :

الهدف من البحث هو لتقييم جرعة الدخول للمرضى الذين يتعرضون إلى إشعاع لفترة طويلة بجهاز الفلوروسكوبي أثناء تواجدهم في مركز تفتيت الحصى .العوامل الرئيسية التي تم تسجيلها في هذا البحث هي زمن التعرض للإشعاع و فولتية الأنبوبة ، تيار أنبوبة الأشعة السينية .خمسون حالة تم تسجيلها في هذا البحث حيث تم حساب جرعة الدخول لهم باستخدام معادلة رياضية تربط بين فولتية و تيار أنبوبة الأشعة و المسافة بين المريض وأنبوبة الأشعة بجرعة الدخول.النتائج أوضحت بان جرعة الدخول كانت وبشكل واضح عالية نسبة إلى الفحوصات الإشعاعية الاعتيادية.

Introduction:

Diagnostic X-rays are used so extensively in medicine that they represent by far the largest induced source of public exposure to ionizing radiation. Patient radiation dose from conventional radiographic procedures ranges from 0.1 mSv to 10 mSv, resulting in a collective dose to the population that can be significant [1].

Fluoroscopy guided medical procedures are an essential part of the contemporary practice of medicine. By and large, the risk of stochastic or deterministic injury as a result of radiation exposure during these procedures is low.[2]

Fluoroscopic procedures may involve high patient radiation doses. The radiation dose depends on the type of examination, the patient size, the equipment, the technique, and many other factors.

The performance of the fluoroscopy system with respect to radiation dose is best characterized by the receptor entrance exposure and skin entrance exposure rates, which should be assessed at regular intervals. Management of patient exposure involves not only measurement of these rates but also clinical monitoring of patient doses.[3].

A surface dose (skin 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]
Entrance skin dose (ESD) is a measure of the radiation dose absorbed by the skin where the X-ray beam enters the patient. ESD can be measured directly with thermoluminescent dosimeters or computed from measurements made with an ionization chamber.
Kerma (kinetic energy released in matter) is defined as the amount of energy transferred from the incident X-rays to charged particles per unit mass in the medium of interest. Kerma includes any energy subsequently given up as photons (ie, bremsstrahlung), but excludes any further energy transfer to other charged particles.
Exposure, a somewhat outdated concept, represents the amount of energy initially transferred from the incident X-rays to charged particles per unit mass of air.
Exposure excludes any further energy loss by the charged particles that is subsequently given up as photons or to other charged particles [5].
During fluoroscopy the dose rate to the patient is greatest at the skin where the X-ray beam first enters the patient. Although most literature has begun to report dose rate in milligray per minute, existing regulations still specify limits in terms of an exposure rate (roentgen per minute). The entrance exposure limit for standard operation of a fluoroscope is 10 R/min (100 mGy/min). Some fluoroscopes are equipped with a high-output or "boost" mode, and the limit for operation in this mode on state-of-the-art equipment is 20 R/min (200 mGy/min) .There is no limit on entrance exposure rate during any type of recorded fluoroscopy, such as cinefluorography or digital acquisitions[6].
A typical fluoroscopic entrance exposure rate for a man of medium build is approximately 3 R/min (30 mGy/min) .Dose rates of up to 50 R/min (500 mGy/min) and higher may be encountered during recorded interventional and cardiac catheterization studies, such as those that involve a series of multiple, still-frame image acquisitions[6].A very long examination involving 30 minutes of fluoroscopy time could result in doses of <90–1,500 rad (900 mGy to 15 Gy). Although a dose of 90 rad (900 mGy) will most likely produce no apparent effects, 1,500 rad (15 Gy) can cause severe skin burns that develop slowly and may take months to heal. Dermal atrophy may develop after several months and become more severe after a year. At doses in excess of about 1,800 rad (18 Gy), more severe skin burns involving dermal necrosis may slowly evolve over many months . Physicians must know how to minimize radiation doses to patients to avoid short-term (<2 years) radiation-induced injuries (eg, burns) and long-term (>2 years) harm (eg, cancer).[7].

Patients And Methods:

µpatients were adjusted in supine position during fluoroscopy. The X-ray tube kilo- voltage (kv) ,tube current (mA), and time of exposure were recorded for each patient and then the entrance dose can be calculated in accuracy of (95%) by the following equation[8] :

$$ED(\mu Gy) = \frac{836 \times (Kvp)^{1.74}}{(SSD)^2} \frac{\times (mAs)}{} \times \left[\frac{1}{T} \pm 0.114 \right]$$

where :

ED: entrance dose(µGy)
T: is the total filtration in units of (mm).
S.S.D: source surface distance .
(KVp): refer to the X-ray tube voltage in unit of kilovolt(kv).
(*m*As): refer to the product of the electrical tube current in unit of milliampere (*m*A) multiplied by the time of exposure to X-ray in second(*s*.)

*(KVp and mAs) had been taken from practical work in the ESWL unit in Al-sadder teaching hospital .

Results

Table(1):
show the exposure factors (tube current and tube voltage and time of exposure) and the value of entrance dose(mean)

Parameters values	Minimum value	Maximum value	Mean
KV	65	110	87.5
mA	3.9	8	5.75
Time of exposure (Second)	60	150	105
Entrance dose (mGy)	112.174	810.882	461.528

Table(2):
Show the frequency of the X-ray tube voltage(KVp) used in examination

Tube voltage(KV)	Frequency
60-69	6
70-79	10
80-89	12
90-99	11
100-110	11
Total	50

Table(3):
Show the frequency of the tube current (mA) used in examination.

Tube current(mA)	Frequency
3-3.9	1
4-4.9	1
5-5.9	16
6-6.9	22
7-8	10
Total	50

Table(4):
Show the frequency of time of exposure to the X-ray during the examination

Time of exposure	Frequency
60-79	7
80-99	25
100-119	3
120-139	8
140-159	7
Total	50

Table (5):
Show the frequency of the entrance dose calculated for the patient undergoing fluoroscopic examination(mGy).

Entrance dose	Frequency
100-	8
300-	27
500-	12
700-	3
Total	50

Discussion:

Fluoroscopy is used to create real-time images for diagnosis and to guide other medical procedures. Modern fluoroscopic x-ray equipment is subject to strict governmental regulations, but these regulations do not guarantee that radiation is safely used on patients nor that the physician operators and support staff are protected from risk of radiation-induced injury.
The results show that the entrance dose was significantly very high in comparing it to the that results obtained by [Sandilos,et al 2006],in which the mean value of entrance dose was(76.5mGy),where our mean entrance dose(444mGy) , so we thing that the difference is belong to method of estimating the entrance dose and long exposure time ,where[Sandilos,et al 2006] using TLD dosimeters to estimating the dose and short time of exposure .

Entrance dose also estimated by [Tsapaki, et al 2007] from interventional radiology for patients to determine whether this dose within permissible range or not .

[Persisnak 2002] calculate the patients effective dose from fluoroscopy guided extrcorporal shockwave lithtripsy procedures(0.76 mSv- 1.71mSv).

[Parland 1998] was estimate the entrance dose for patients undergoing interventional radiological procedures ranging from (110 mGy to 670 mGy).

Conclusion:

Dose monitoring helps to ensure that the best possible protection of the patient is maintained at all times and provides an immediate indication of incorrect use of technical parameters or equipment malfunction. During fluoroscopy ,the KV and mA are very important parameters which controls the quality of X-ray picture on the screen .

The entrance dose can be maintained to minimum value by reducing the exposure time where the relation-ship between the entrance dose and time linear.

In this study mathematical is used for entrance dose calculation .This study demonstrated that using the results from the quality control procedure to estimate the entrance dose could be an alternative reliable and cheap method for patients dose monitoring in the every day routine of a diagnostic radiology department.

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