Investigation into Radiation Doses to Patient During Diagnostic Imaging

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Abstract:

Investigation in doses delivered to patient during an X-ray imaging is carried out. From the data obtained, the Entrance Surface Dose (ESD) is calculated and compared to the Reference Dose Levels of other countries (UK, Australia and the US). The results show 93% of chest examination was cases of overdose, while some other examinations had 8.5% overdose by more than 3 times. The results suggests that during X-ray imaging patients receive doses more than the reference level at the Sulaimani Hospital.

Keywords:*Radiation Dose, Dose Reference Level, Entrance Dose,Dose during diagnostic imaging*.

Introduction:

There is no doubt over the past 60 – 70 years, advances in Diagnostic Radiology (DR) have improved patient care and it has contributed to the decrease of patient mortality due to cancer and other illnesses. Thanks to the advancement of technology in this field, clinicians and medical staff have been able to offer more accurate and better treatments to patients. This certainly is true especially after the invention of MRI and CT [1, 2].

One of the most frequently used modality in DR is X-ray. There are various justified reasons for this, including the provision of good clinical information, it is economic to run and to maintain, easy and fast to use. X-ray has played a very important role in the advancement of DR; whether this is due to the invention of better detection techniques or other technology which form part of an X-ray unit. Despite its success in this field, X-ray also have a drawback. When traversing through a medium, such as tissue, it delivers small amount of energy within the tissue, this means an X-ray deposits a small amount of dose in the patient. There are a very large number of studies that discuss the relationship between X-ray exposures in a DR examination to the risk of cancer development [3, 4, 5].The doses that are delivered during a DR examination although very low, however there are numerous works that show a relationship between this low radiation dose to the possible development of cancer in the future [6, 7, 8, 9]. This lead various organization such as the International Commission on Radiation Units & Measurements (ICRU), International Commission on Radiological Protection (ICRP), International Atomic Energy Agency (IAEA), United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) and other local governmental health and safety agencies to put various protocols in place to advice medical staff and radiologist to be aware of such risk. one of the advices and requirements that are put in place by these organizations, is the limitation of a dose delivery to patient in such a way that dose must be kept at minimum while making sure through this dose limitation, clinical information are not lost, therefore optimization between dose delivery and clinical information is critical[10].

To avoid over dose of patient during diagnostic imaging, Dose Reference Level (DRL) is used. The ICRP first discussed the DRL in hospitals and healthcare centers then it defined the term more precisely including its application in its later reports [11, 12]. The DRL is used by medical staff based in hospitals to investigate doses that exceed the reference level set before. Through these referencing levels, a correct course of action will then be taken by various specialized staff at the center to reduce unnecessary over dose. The ICRP has set the referencing level to act as an indicator for dose level, above which an investigation should be carried out [12].The purpose of the DRL is advisory. It is a method of investigation level to identify and detect unusually high levels of doses, which has to be reviewed and investigated by appropriate and responsible department in charge, if these levels are consistently exceeded [13,14]. There are many published papers reporting DRL data for local health centers and hospitals [15], the main data and records come from the western European countries, Australia and the US where the quality control and assurances are high and followed on regular basis.

However in a country like Iraq and Kurdistan Region, there is no active quality control in the health system (at least none in the field of radiation protection), There is no DRL in any of the local hospitals in the country, cases of over dose and irradiation cannot be traced or investigated. The lack or nonexistence of a quality control and assurance in the Iraqi and Kurdistan Region health system puts patient at risk.

Method:

In light to the ICRP guidance, a study of dose delivery to patient in one of the hospitals in Kurdistan Region during X-ray diagnostic examination is carried out for the first time. Over the period of three months, data at Sulaimani Hospital, in the city of Sulaimani, Iraq were collected. The hospital has three main department which uses X-ray, these are the Emergency department, the Teaching department and the Radiation Centre.

Various methods are used to measure and calculate the DRL. One of these methods that are used for dose monitoring and calculation purposes is the Entrance Surface Dose (ESD) [16]. We have used the ESD method and it is calculated from equation 1[17]:

$$ESD = C\left(\frac{kV_p}{100}\right)^2\left(\frac{mA.s}{1000}\right)\left(\frac{2.5}{mmAl}\right)\left(\frac{100}{SSD}\right)^2 \quad (1)$$

Where C is a constant, kVp is the kilo voltage, mA.s is the milliamp.Sec (exposure), SSD is the Source to Surface Distance and mmAl is millimeterAluminum filtration. In this work the ESD for each patient and examination is calculated using the data obtained and since there is no national DRL, the ESD values that are calculated will be compared to the values that are accepted worldwide by various international organizations.

Results and Discussion:

Over the period of three months, in total 339 x-ray examinations for 201 patients have been collected. Values of kV, mA.s. SSD and the Al filtration were measured, which are then used to calculate the ESD. The result of several examinations are presented in Table-1.It is evident for some of the examinations there is a large range between the maximum and the minimum dose, especially for neck, elbow, knee, lumbar and pelvis, were the minimum and the maximum differ by a factor of 7.5, 27.8, 61.8, 4.6 and 8.6 respectively.

Table 1. Data for several examinations and the calculated ESD

Examination Type	No. of Examination	Min Dose (mGy)	Max Dose (mGy)	Mean Dose (mGy)
Chest	29	0.154	0.665	0.407
Skull	9	0.529	0.776	0.667
Ankle	21	0.065	0.124	0.092
Neck	4	0.081	0.611	0.459
Elbow	19	0.046	1.280	0.310
Foot	36	0.036	0.097	0.052
Forearm	15	0.054	0.106	0.074
Knee	35	0.052	3.213	0.287
Lumbar	19	0.970	4.498	2.431
Pelvis	10	0.303	2.602	1.332
Wrist	23	0.039	0.193	0.095

The values of ESD are calculated and the results are presented in Table 2. There is no local or national DRL in Iraq and Kurdistan Region, we have therefore compared these data to the American Association of Physics in Medicine /Radiological Society of North America (AAMP/RSNA respectively), the Australian Radiation Protection And Nuclear Safety Agency (ARPANSA) and a work by B. F. Wall [20]. A difference can be seen between these references, this however is natural as the DRL are a local guidance and not an international referencing point.The ESD values of 0.2 mGy for chest examinations stated by the references (Table 2) are well below the calculated values of ESD for chest examination in Sulaimani Hospital with an average of 0.407 mGy. Although average sometimes can be misleading, to further show the high level of dose delivery for chest examination at the hospital, a normal distribution was plotted for this examinations as it can be seen from Figure 1.A. When this distribution is compared to the values in Table 2. a clear right shift can be seen which indicates 93% of the examinationsare overdose. Only two out of 29 examinations are below the DRL by the references in Table 2.

When the same distribution is plotted for other examinations, such as knee, an inconsistent pattern emerged as it is evidentfrom Figure 1.B. The inconsistency indicates a lack of understanding ofradiation interaction with tissue by staff who operates on the machines

Table 2: * Values from [18], †from [19] and †† from [20], **The LAT value are not included in this table, since we have not recorded any data for LAT. *** Only LAT values are included, since the data we recorded were only LAT

This isa major concern since Figure 1.B. indicates 8.5% of patients have received3 times higher dose than the average, while 23% of the examinations are well above average.Of all the examinations, ESD of pelvis and skull is lower than the references. This is a positive outcome since staff who operate the machines have very little or no

Examination	This Work	Other Work		
	Calculated ESD(mGy)	ESD* (mGy	ESD† (mGy)	ESD ††
Chest	0.154 – 0.665	0.14 – 0.20**	0.2	0.2
Foot	0.036 – 0.097	0.45	-	-
Lumbar	0.970 – 4.498	5.00	1.6 - 3	6
Pelvis	0.303 – 2.602	5.00	3	4
Skull	0.529 – 0.776	1.50***	1.5	1.5

information on the radiation interaction with tissue. Not only this, there is also the lack of activity or nonexistence of radiation protection agency or committee which can investigate,monitor and follow these procedure

Fig. 1-A

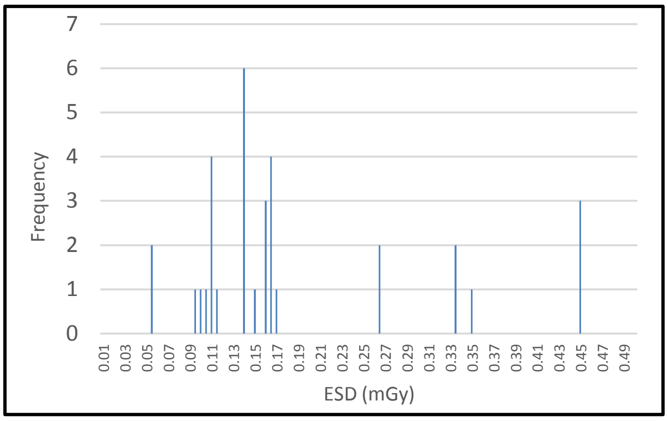

Fig. 1-B

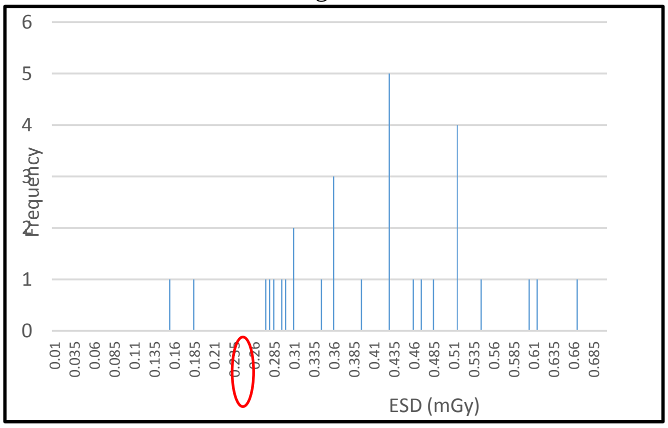

Fig. 1 A normal distribution of ESD for A. chest examination and B. knee examinations. The red circle in Fig. 1A indicates the references set by [19, 20].

Conclusion:

In carrying out this work, the results show that there were substantial amount of overdose, under dose and for a particular examinations the range of doses that are used is very large. All these may attributed to the nonexistence of a Radiation Protection Agency which can oversee, control, monitor and follow the uses of radiation for medical purposes. When visiting the hospitals, none of the staff was using the safety apron which was another important problem in the diagnostic process.

The nonexistence of national radiation protection standards necessitates a long term project to find and establishing a local DRL which need cooperation between all the radiation experts and workers.

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