The Ethiopian Journal of Health Development

Original article

Skin Entrance dose to patients from routine P-A chest X-ray examination, Radiology Department, Tikur Anbessa Referral Hospital

Mulubrihan Alem, Asfaw Atnafu

Department of Radiology, Faculty of Medicine, P.O. Box 9086, Addis Ababa, Ethiopia **Ethiop. J. Health Dev. 2001;15(2):145-151**

Abstact

Background: Radiation of any amount is potentially hazardous and it should be minimized as much as possible during health care delivery.

Objective: To determine and assess the variation of the dose received by patients undergoing chest x-ray examination, and to provide a useful baseline data to evaluate the dose to the general public from CXR.

Methods: Radiation doses received by 100 adults patients undergoing postero-anterior/P-A/ chest x-ray examination have been measured using thermoluminescent dosimeter / TLD/.

Result: The average skin entrance dose was 1.24 mGy , ranging from 0.68 to 1.98 milligray /mGy/. TheBody mass Index / BMI/ for 98% of the patients was below 85^{th} percentile excluding obesity as a factor for the high entrance dose observed.

Conclusion: The dose received from P-A chest x-ray obtained in this study is significantly high. A further detail study covering the whole country, both private and governmental institution, to assess the practice and come up with lasting solution is highly recommended: [*Ethiop. J. Health Dev.* 2001;15(2):145-151]

Introduction

The biological effects of all forms of ionizing radiation can be either somatic or hereditary. No threshold dose exist and the effect may be demonstrated at a very low dose levels because of the random nature of radiation effects(1,2). The current radiation protection philosophy is thus the dose should be kept as low as reasonably achievable

The collective dose from medical exposure has been estimated to represent the largest single man made contribution to both somatic and the genetically significant dose equivalent (GSD). In UK it represents 31% of the somatic and 9% of the total GSD, and 95% and 85% respectively of the man made contribution. (3,4). The largest dose contribution, among man made radiation sources, comes from medical irradiation of which diagnostic radiology accounts for the 90% (5,6).

In order to minimize the risk, its use should be both justified and optimized. The benefit must always be greater than the risk involved. To this effect knowledge of the dose received during each x-ray procedure is essential for the assessment of radiological hazards and help stimulate the awareness of radiological personnel on good radiation protection practice (6-8).

As chest x-ray is the most frequently performed radiological examination the contribution to the population dose is substantial. It is therefore important to measure dose received by patients from such a common radiological examination. Routinely the dose received by radiation workers is monitored monthly using TLD. The dose received by patients during radiological examination is equally important if not more from radiation protection point of view. This will give important information on the collective dose that the public is getting from diagnostic radiology and it also helps to estimate the risk involved.

In Ethiopia so far there is only one study conducted on 20 patients at two hospitals, TARH & Zewditu Memorial, regarding dose received by patients from routine diagnostic radiological procedure using a low KV technique (9). There is no guideline with respect to the maximum radiation dose that is permissible for different diagnostic procedures performed taking in to account the social and the economic factors of the Nation.

The objective of this study is then to determine and assess the variation of the dose received by patients undergoing chest x-ray examination, at TARH, radiology Department and to provide a useful baseline data to evaluate the dose to the general public from CXR examination.

Methods

This study was conducted at TARH Radiology Department on hundred adult patients referred for P-A chest x-ray between March - July 1998. Patients coming for P-A chest x-ray during normal working hours on the first Tuesday of the month were included and entrance skin dose was measured on the first 20 patients. X-ray unit in room number 6 of the Department was used for this study. The unit is a 3-phase fully rectified Schimadizu machine assigned for chest x-ray procedure exclusively. Before the study was commenced quality assurance tests were done by experts from National Radiation Protection Authority. The study was explained to the practicing radiographers in order to get their full cooperation and reassured that their name will not appear on the data record sheet. The procedure was explained to each patient and permission, to apply the dose measuring devices as well as recording various data, was obtained. At the Department low KV technique and 150 cm film focus distance (FFD) are used for all chest x-ray procedures. In this study the x-ray parameters and procedures followed by the department were adopted without further modification.

Lithium fluoride pellets obtained from National Radiation Protection Authority. Among 100 TLDs made available 24 were selected based on their response to a known dose from cobalt - 60 source repeatedly and also after cross checking them with P-T-W Cony dosimeter on a phantom. The selected TLDs were all from the same batches. The dimension of the TLD pellets was small that it will not caste image to interfere with the interpretation of the radiographs. The sensitivity of the TLDs used in this study is 95%.

Each TLD had an identification number and this was entered into the data sheet of individual patient. One TLD pellet was attached to the patient's skin at the center of the entrance beam axis. Before and after each exposure the TLD pellets were carefully handled and kept away from any source of radiation.

The reading of exposed TLDs was performed at National Radiation Protection Authority on the day of exposure using a computerized Vinten Solaro machine, which converts the reading automatically to Milli-Gray (mGy). The accuracy of the reading equipment is 99.3%. In order to remove all residual signals appropriate annealing cycles were adopted before the reuse of the TLDs. Annealing was performed by using suitable oven and temperature, which can achieve a threshold detection rate below 0.02 mGy. TLD sensitivity was crosschecked by P-T-W Cony dosimeter at different intervals during the study period. Finally the data was aggregated and analyzed by the investigator.

Results

Skin entrance dose of radiation during P-A chest x-ray procedure, was measured using TLD on 100 adult patients. The demographic characteristics of the patient population studied are shown on table1. The median age was 35 years, with range 15- 87 years. The majority of the patients i.e. 83% were below 50 years of age, with the male to female ratio of 1.5: 1. About 50% of the patients were from Addis Ababa while the rest were from the regions. Of those from the regions 84% were from Oromia, Amhara and South people.

Sixty four percent of the patients studied had chest x-ray exposure already. Of the previously exposed 35 patients had more than one exposure. Three were exposed previously but they didn't know the number of times. Of those who remember the number of previous exposures, two patients had 10 and 11 exposures respectively (table 2). The indications for CXR was tuberculosis accounting 54%, followed by pneumonia and malignancy, constituting 14% each (table 2).
The mean body mass index (BMI) was found to be 21.3, ranging from 12.96 to 29.00. The BMI in 98% of the study population was below 85^{th} percentile, for males it was below the 85^{th} percentile and for females 5% fall above the obesity line (85^{th} percentile) as shown on table 3.

Table 4 shows the frequency of different mAs and KV applied. Seventy KV was the most frequently used (for 51 patients) and ranging from 50 - 70 KV. The smallest applied mAs was 14 while the largest was 45 mAs.

Table 5 shows skin entrance dose as measured using TLD applied over the center of the entrance beam. The mean entrance dose measured was 1.24 mGy; ranging 0.68 to 1.98 mGy.

Discussion

Unpublished report from Tikur Anbessa Referal Hospital (TARH) on a cross sectional review of 6 months registration book showed Chest X-ray /CXR/ accounts 55.9 % of radiographs taken, and it is expected to be even more frequent in rural setup. In England CXR contributed 46% of all radiological procedures (8).

As it is demonstrated in table 1, 76% of the adult population referred for chest x-ray examination is below 40 years of age. Both the genetic and somatic risks of diagnostic x-ray exposure are enhanced when the average patient age is lower, i.e. the younger the patient has a higher child expectancy and a longer subsequent life expectancy, during which time delayed somatic effects of radiation may develop into the clinical overt stage (1,4).

The skin entrance dose (table 5) when compared to the previous study conducted at Black Lion Hospital by Mengesha W etal is 0.94 mGY. This can be explained on the fact that in the previous study the applied KV is pre determined while the present study followed routine department's protocol. The average skin entrance dose obtained in this study was 1.24 mGY which is unacceptably high dose compared to the standard dose set by Commission of European Communities for PA CXR, which is 0.3 mGY (9). A pilot survey conducted by the National Radiological Protection Board in UK in 1992 revealed that the minimum skin entrance dose from PA CXR was 0.03 and the maximum 0.27 mGY (10). The skin entrance dose studied in Ghana by Schandorf C. etal during P-A chest x-ray at 6 hospitals ranged from 0.4 mGY - 0.53 9GY(9). They used low KV technique, and longer FFD that is 200 cm.

In general, the FFD used in current study compared to that of Argentina, Brazil, Czech Republic and Ghana is shorter. This can partly explain the high skin entrance dose because as the FFD increases the beam will become harder as a result of air filtering out the weaker beam from the x-ray spectrum. The high skin entrance dose observed can be explained on the bases of the low KV and the short FFD used among the many other factors that are known to influence skin entrance dose. Studies showed that breast and thyroid radiation doses are directly proportional to skin entrance dose according to Shrimpton P.C etal (9). This there fore increases the radiation-induced risk to these radiosenstive organs in our patients. Dose measurements done in other study have demonstrated that breast and thyroid glands received the highest dose from chest x-ray compared to other radiological procedures. Radiation exposure has a cumulative effect, repeated exposure carries higher risk by it self. In this series 67% of the patients studied had previous chest x-ray exposures. One would also expect exposure as the indications for the chest x-ray were chronic diseases (89%) that require follow-up x-ray examination (table 2). Two patients were already exposed 10 and 11 times respectively from P-A chest x-ray. Taking the average dose measured at surface entrance in this study the two patients had received about 13.64 mGy and 14.88 mGy, including the current exposure, respectively. It is known that up to a certain dose level the radiation risk, for both genetic and somatic stochastic effects, increases with an increase in dose received (1). This then raise the issue of considering seriously the risk and benefit of unselected indiscriminate use of radiation sources.

In addition the operational condition of radiological equipment is among important factors known to influence dose to patients at any radiological investigations. In line with this regular quality assurance of machines and radiological procedures are important to reduce dose to patients. The quality of film employed, applied mAs, kilo-voltage selected and the skill of the operator are also important determinant factors for patient dose reduction (11) . In this study in 71% of the cases 24 mAs or more was applied. As clearly demonstrated on table 4 there is no relation between the applied mAs and kilo - voltage selected. Looking at table 4 one could observe that the two were haphazardly applied which also partily contribute to the high skin entrance dose observed. The body mass index (table 3) of all male and 95% of female patients was below 85th percentile while it was only in 5% of the females that the BMI was falling above 85th percentiles of obesity line. As the patients studied are not obese, it is unlikely that obesity contributed for the high skin entrance dose observed. Therefore changing the routine technical protocol like high KV technique, increasing FFD etc seems the immediate practical approach to reduce skin entrance doses

But any action on dose reduction should ensure that, at least, no diagnostic information is lost in the process. Dose reduction without loss of diagnostic information implies a successful process of optimization and quality assurance which will lead to an improved use of the available x-ray equipment and film (12).

Supervision on radiographers routinely and upgrading on their knowledge is important measure for reducing dose to patients. Doctors must make sure that the requested radiological procedure is indispensable for a particular patient's management. It is only then that one can say the benefit out weighs the risk.

National Radiation Protection Authority, as a regulatory body in the country, should forward guideline regarding the maximum dose permitted for each diagnostic radiological procedure in order to protect the public from unnecessary dose exposure. Machines and radiological practices that are not satisfying the minimum set requirements shouldn't be licensed and permitted to practice.

In conclusion the current study done in a teaching referral hospital showed unacceptable high skin entrance dose during PA CXR. One would definitely assume the situation to be worse in smaller and rural hospitals and some private institutions. This then necessitates a wider study at a national level to make planned intervention.

Acknowledgments

I am indebted to all Radiology Department staff and colleagues who assisted and encouraged me all along the process. A special thanks goes to Ato Hailu Wolde and Dereje Anbesse, both from Radiation Protection Authority, who helped me in machine calibration TLD reading and in all other measurements. I would like to extend my special thanks to Radiation Protection Authority for allowing me to use their laboratory and for material assistance.

Tables

Table 1: Age and Sex distribution of the referred patients for P-A chest X-ray to Tikur Anbessa Referral Hospital (TARH), March-July, 1998

Age	Male		Female		Total
	Number	Percent	Number	Percent	
11-20	13	21.7	7	17.5	20
21-30	18	30.0	11	27.5	29
31-40	19	31.7	8	20.0	72
41-50	5	8.3	2	5.0	7
>50	5	8.3	12	30.0	17
Total	60	100	40	100	100

Table 2: Diagnosis of the referred patients for P-A chest x-ray by referring physicians and the status of previos chest x-ray exposure

Diagnosis by referring physician	**Number of previous chest x-ray exposures** I	II	III	IV	V	>V	Do not rem.	**No Chest x-ray Exposures**	**Total**
Tiberculoses	19	6	5	1	2	3	3	15	54
Pneumonia	3	1	0	0	0	0	0	7	11
Malignang diseases	1	2	0	3	1	1	1	2	11
CVS diseases	2	2	1	0	0	1	1	4	11
Bronchial asthma	1	1	0	0	0	0	0	1	3
Others*	4	2	0	0	0	0	0	4	10
Total	30	14	6	4	3	5	5	33	100

Table 3: Frequency distribution of body mass index (BMI) of Study population

Body mass index	**Male**		**Female**		**Total**
	Number	**Percent**	**Number**	**Percent**	
<15	1	1.67	1	2.5	2
15.00-17.00	4	6.67	2	5.0	6
17.01-19.00	12	20.00	8	20.0	20

19.01-21.00	11	18.33	8	20.0	19
21.01-23.00	13	21.67	5	12.5	18
23.01-25.00	11	18.33	9	22.5	20
25.01-27.00	8	13.33	5	12.5	13
>27.00	0	0	2	5.0	2
Total	60	100	40	100	100

Table 4: Milli-Ampere-Second (mAs) used against applied kilo voltage (KV) for the 100 patients studied

Applied KV	Mill - Ampere second applied								Total
	14 mAs	15 mAs	16 mAs	20 mAs	24 mAs	30 mAs	36 mAs	45 mAs	
50	2	0	0	0	0	0	1	0	3
55	1	1	0	0	0	0	0	0	2
60	3	2	3	0	1	1	1	8	19
65	1	0	5	2	2	5	5	5	25
70	0	1	5	3	11	17	8	6	51
Total	7	4	13	5	14	23	15	19	100

Table 5: Skin entrance dose in milli-Gray (mGy)

Age group in years	Reading in mGy							Total
	Less than 0.81	0.81 to 1.00	1.01 to 1.20	1.21 to 1.40	1.41 to 1.60	1.61 to 1.80	1.81 to 2.00	
11-20	0	7	6	2	0	0	2	17
21-30	1	4	11	6	3	1	1	27
31-40	0	7	10	5	1	3	2	28
41-50	0	0	7	4	2	1	1	15
>50	0	1	6	2	2	2	0	13
Total	1	19	40	19	8	7	6	100

Table 6: Clinical impression by referring physician verses radiological diagnosis

Clinical impression verses radological diagnosos	**Number**
Same diagnosis	60
Different diagnosis	35
No diagnosis given by requesting physician	5 4
Total	100

Figures

References

1. Awwad KH. Radiation oncology, Radiobiology and physiological perspectives, 1990;2.
2. Coregy CE. Radiation risks with diagnostic x-ray; Radiology, 1976;123:447
3. Herbert WW. Is low dose radiation harmful?; Memorial Symposium, 1981.
4. Committee on radiological hazards to patients; Radiological hazards to patients; Second report of the committee, Scotland, 1960.
5. World Health Organization; Effective choices for diagnostic imaging clinical practices, Technical Report Series WHO Geneva, 1990:795.
6. Whallen JP and Balter S. Radiation risks in medical imaging; year medical publishers, INC; 1984.
7. Barrett J. ADRC; An investigation of radiation dose level to patients during lumbar spine examination; Radiology today 1993;59(675):20-22.
8. Russell J.G.B. Radiation protection in Radiography in United Kingdom, British Journal of Radiology 1986;59(704):747-749.
9. International Atomic Energy Agency; Radiation dose in diagnostic radiology and methods for dose reduction, Report of coordinated research programme jointly organized by Atomic Energy Agency and the commission of the European comities, April, 1995.
10. National Radiological Protection Board; Measurements in Diagnostic Radiology, UK Victoria, 1992.
11. D. Noreen Chesney; Muriel O. Chesney, Radiographic Imaging, 1984. Shrimpton .P.C et al; Dose to patients from routine diagnostic x-ray examinations in England; BRJ, 1986;59(704):749-758.
12. Supe SJ. et al; Exposure to Indian population from diagnostic radiology; Bulletin of radiation protection, 1993;16(1&2):56-58.