A VIEW OF THE STATUS OF RADIATION PROTECTION, PATIENT DOSE AND STAFF AWARENESS IN DIAGNOSTIC RADIOLOGY IN NEPAL

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Abstract

Nepal has a long history of medical radiology (1923) but unfortunately, we still do not have any radiation protection infrastructure to control the use of ionizing radiation in the various fields. Recently, Nepal became a member of the IAEA and this will certainly support and speed up the creation of appropriate conditions. The aim of this study was an assessment of the radiation protection in X ray diagnostic departments, including patient skin entrance dose diagnostic imaging. The patients' skin entrance doses were measured with TLDs for chest and lumbar spine investigations. This is the first attempt in Nepal to make spot measurements of this kind.

Measurements were also performed to assess the status of radiation protection barriers and general conditions in the same radiological centers. Questionnaire for radiation workers were used, radiation dose levels were measured and an inventory of availability of radiation equipment made. Another aim of the study was to create awareness in the workers about possible radiation health hazard and risk. It was also important to gain an insight of the level of understanding of the personnel in order to initiate steps towards the establishment of Nepalese code of radiological practice. Altogether 12 hospitals including 22 X ray and 4 CT rooms were monitored. 96 radiation workers completed the questionnaire. Most of the general X ray and CT working areas are safe but some area needs more protection. Only one of the surveyed hospitals has a regular personnel monitoring system. There is no quality control program in all surveyed hospitals, only a maintenance contract with the company. Therefore QC program should be performed on the X ray equipment regularly, following international protocols. TLD results show that there is a large variation of skin entrance doses for the same kind of investigation and at some centers patients receive relative higher doses. There is a need to better verify the quality of the image in relation to the dose received.

1. 1. Background

Recently, a tremendous development has taken place in the field of X ray diagnostic imaging. Newer modalities are being introduced in major hospitals and the latest radiological equipment are being imported. This quantitative increment may have a positive impact on the health service system of the country; but the lack of control is a serious problem. At present there are more than 30 CT scanners and about 900 X ray units in the country; there are about 300 professionals working in this field. Due to the lack of radiation protection laws/regulations and infrastructure~~s~~ in Nepal, there is no legislative body or any radiation act to set standards for radiation protection, nor are there radiological activities as well as any monitoring system. Official records of the exact number of the radiological facilities in operation are also lacking. This is the first attempt in Nepal to make spot measurements of the skin entrance dose received during conventional examination in X ray by using TLD.

Ionizing radiation is used in diagnostic imaging, external beam radiation therapy, brachytherapy, and nuclear medicine to diagnose and treat a number of common conditions. To ensure the safety of patients, providers, and surrounding staff members, it is important that the health care community become familiar with the terminology, common equipment, and standard practices used in radiation safety and monitoring [1].

2. OBJECTIVES OF RADIATION SURVEY

1. To investigate the status of radiation safety mechanisms, procedures and practices;
2. To ensure proper working condition and status of radiological equipment;
3. To assess whether weekly equivalent dose received by the radiation workers working around radiation area are within the dose limits recommended by ICRP or not [2, 3];

4. To understand the personnel views of radiation protection through questionnaire.

3. MATERIALS AND METHODS OF THE SURVEY

Three ways were applied to assess the status of radiation protection, quality control activities

i) Questionnaire for radiation workers;
ii) Radiation level measurement;
iii) Exposure of TLD (from “Nuclear Service” Bologna).

The questionnaire for radiation workers consists of twenty-five questions seeking information regarding professional responsibility, protection training, personnel dose monitoring, institutional and self-motivation towards radiation safety, etc. In addition, the questionnaire gives also some information about the general understanding of radiation protection.

4. ANALYSIS OF RADIATION SURVEY

To find the level of radiation at the radiological facilities of different public and private hospitals, Roentgen Gamma Ray Dosimeter (RGD 27091) and FAG FH40F1 were used. To measure the radiation level, six specific locations were selected as indicated:

A: At control console,
B: Outside the X ray room (door closed)/Corridor,
C: Patient’s waiting room,
D: Dark room,
E: Behind the wall where X ray tube is often directed, and
F: Leakage radiation at 1 m form the tube.

The equivalent dose rates in air at different locations at the specified reference points were measured. A scattering medium was used and measurement behind the chest stand wall was done without a patient or a phantom. The set of measured points are shown below (Fig. 1).

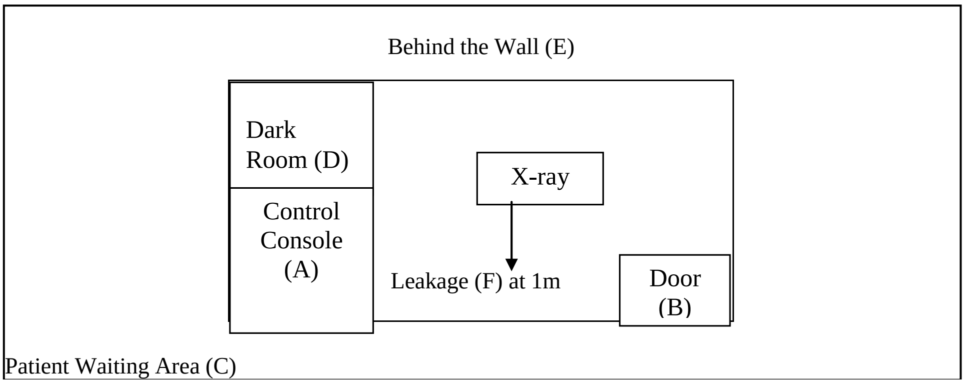

FIG. 1. Typical layout of the X ray room

12 different hospitals were selected for the survey and the TLD irradiation.

4.1. Dose calculation

To measure the radiation level in different areas, consider the different characteristic parameters of radiation, such as kilo volt (kV), mille-ampere (mA) and time (s). The workload in each unit could be calculated as

$$\sum_{i} (mA.\min)_{i} \cdot N_{i} \qquad (1)$$

where:

N_i examination number of kind i,

(mA.min) used techniques for examination kind i

To evaluate the radiation level in different areas the following standard is used to find out the workload as published in DIN 6812 [4]:

- For general X ray unit: 160 mA.min/week
- For general X ray unit with fluoroscopy: 1200 mA.min/week
- Mammography unit: 2000 mA.min/week, and
- CT unit: 5000 mA.min/week

To calculate dose level ***H*** **(mSv/week)** we measure dose rate level in each area $\dot{D}(mSv/\min)$ in an exposition at higher kV, mA_m and min_m. Then in each area:

$$H\left(\frac{mSv}{week}\right) = \dot{D}\left(\frac{mSv}{\min}\right) \cdot \frac{1}{I_m(mA_m)} \cdot Workload\left(\frac{mA.\min}{week}\right) \qquad (2)$$

The operational dose limits for ***H*** are as follows:

- For radiation workers: 0.4 mSv/week, and
- For public: 0.02 mSv/week [4].

To measure $\dot{D}$ we used the higher kV, long time (t) to avoid death time of the survey meter or detector.

4.2. Radiation survey

A preliminary radiation survey was done at some facilities in Kathmandu area [5] and it showed up the need to extend the radiation survey in other centers in Nepal to know the status of radiation protection, and the awareness and training of radiation workers.

Radiation survey was done at 22 X ray rooms and 4 CT rooms in department of radiology at 12 different hospitals around Kathmandu Valley. There are different types of X ray units. Among 12 centers surveyed, 2 centers are using manual film processor, 6 centers are using auto film processor and 4 centers are using computerized radiography system. 9 centers are using green film and 3 centers are using blue film. There is no automatic exposure control in all X ray units. We also found that a door and a window near to the X ray tube were not protected.

The parameter taken to evaluate radiation level is about: kV-105 (Evaluating radiation level in worst conditions of irradiation, high energy of irradiation), time (t) = 2 s (death time of survey meter is longer than 0.1 s), intensity (I) = 100 mA. All the readings are taken with a scattering medium.

The following Figure 2 shows calculated dose level (mSv/week) at different specified reference points at X ray rooms at different institutions.

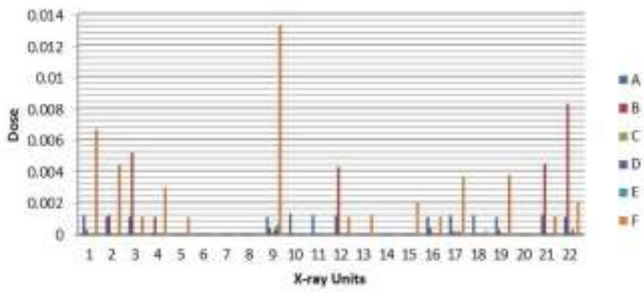

FIG. 2. Dose vs X ray unit.

5. ANALYSIS OF IRRADIATED THERMO-LUMINESCENT DOSIMETERS (TLD)

Measurements were made with TLDs with multiple pallets dosimeters, which allow energy subtraction and are to be considered more reliable. The uncertainty on the TLDs measures is less than 15%. Due to the very limited resources available, it was chosen to make spot measurements for chest and for lumbar spine investigations (AP projections). The patients were selected in order to be "normal size" in Nepal, therefore as "similar" to each other as possible. The TLDs were attached on the patient's body, in the center of the radiation field, following the procedure used in the European Union to make a survey of doses in diagnostic radiology. The same procedure has been repeated in 12 different hospitals for different patients. The values are shown below in Figure 3.

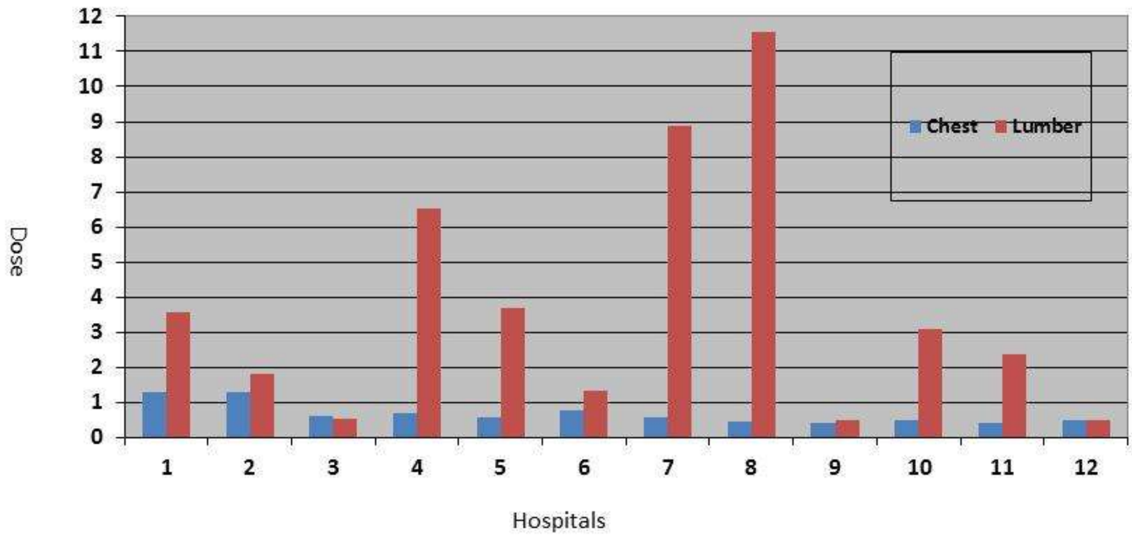

FIG. 3. Patient dose at various institutions.

The highest chest reading is 1.31 mSv with average reading is 0.68 mSv. The highest dose received during lumbar spine investigation is 11.57 mSv and average dose is 3.69 mSv. Radiation guidance dose levels as recommended by IAEA are 0.4 mSv for chest, and 10 mSv for lumbar spine [6, 7]. Therefore, the following considerations follow from a row analysis of the spot measurements values:

a. Radiation doses for chest and lumbar spine appear to be very different in the various hospitals;
b. The Nepalese patient size is smaller than the "standard" patient considered by the IAEA, therefore the doses are expected to be lower;
c. Most of the chest values are slightly higher than the IAEA values, but only two are higher than 1 mSv;
d. The variation in lumbar spine dose values is much bigger, only one value is higher than the IAEA values, on the other hand, there are several very low values which would require accurate evaluation of the image quality;
e. The X ray images were accepted as valid by the respective departments, but it would have been interesting to make inter-comparison evaluations.

In conclusion, the change in result may be due to the status of X ray equipment, examination technique, clinical condition as well as the skill of radiographer. There is concern about the quality of the images and the optimization procedures.

Some quality control test like kV measurement and field verification test (these kind of test tools are the only available) were made. Regarding the kV test only 41.67% of the X ray unit shows acceptable values within plus or minus 5-10% while 33.33% of the X ray unit shows below readings than the given kV and 25.0% of the X ray unit returned above readings. The below and above readings varies from 15% to 20% which is quite unacceptable [8]. Regarding the field verification test more that 90% of the result shows that light field and X ray field are not corresponding.

As expected, there is need for more accurate verification of the quality of the images, and their diagnostic significance, in relation of the dose received. The technical part related to the status of equipment will certainly benefit from a regular QC of the equipment and correction of parameters.

6. ANALYSIS OF QUESTIONNAIRE

Altogether 96 radiation workers including Radiologists, Radiation Oncologists, Radiology and Radiotherapy MD Residents, Radiographers, Dark Room Assistants, and Medical Physicists/Radiation Safety Officers filled in the questionnaire, therefore a reasonable representation of the various hospitals in the country. To evaluate the questionnaire the following programs SPSS 17, PHSTAT2, EXCEL were used. Z test for proportion, descriptive statistics, diagrams are used to interpret data.

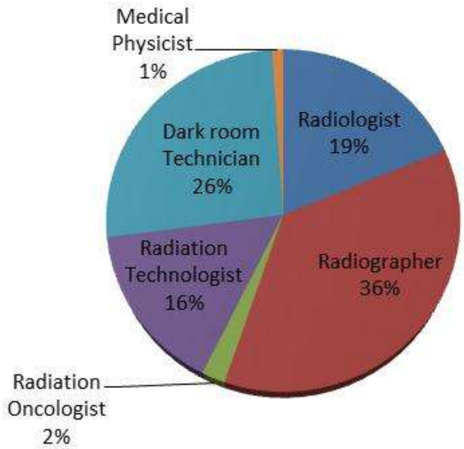

FIG. 4. Distribution of radiation workers.

The maximum number of radiation personnel fall within the age group of 20-30. Regarding awareness about radiation hazard, the responses were: 96.1% picked that they are aware about radiation hazard, 72.2% are aware about exposure rate and only 48.3% know the dose limit for radiation workers [2]. This means around 50% of the radiation workers do not have sufficient knowledge of radiation protection.

In Nepal, there is no radiation protection training/program available in any institution~~s~~ or hospital. At an individual basis 81.4% radiation workers put high priority level in radiation safety, while there are mixed reaction about institutional priority level for radiation safety. Only 66.0% mentioned that there is a symbol of radiation in X ray units. The result shows that around 70% of the radiation workers are not monitored for radiation. Knowing about radiation risk for patient in different clinical cases, the responses are shown in Fig. 5, which indicates that around 63% of the radiation workers have knowledge of radiation risk for the patients in different clinical cases which use ionizing radiation in medical practices.

About the question regarding the impact of different solutions to help workers to be safe and feel safe from ionizing radiation, the responses (Fig. 5) indicate that more than 80% of the radiation workers know that using a protective resource helps to protect them from ionizing radiation.

As a different option for responsible person for informing the public about radiation risk, 81.4% choose radiation protection expert of the hospital. This indicates that Radiation protection expert of the hospital should be the responsible person for radiation protection. This would also indicate that there must be a radiation protection officer in hospitals.

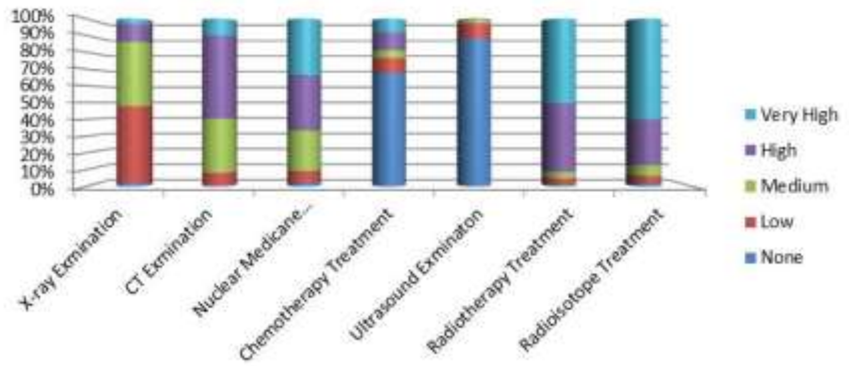

FIG. 5. Radiation risk for patients in different clinical cases.

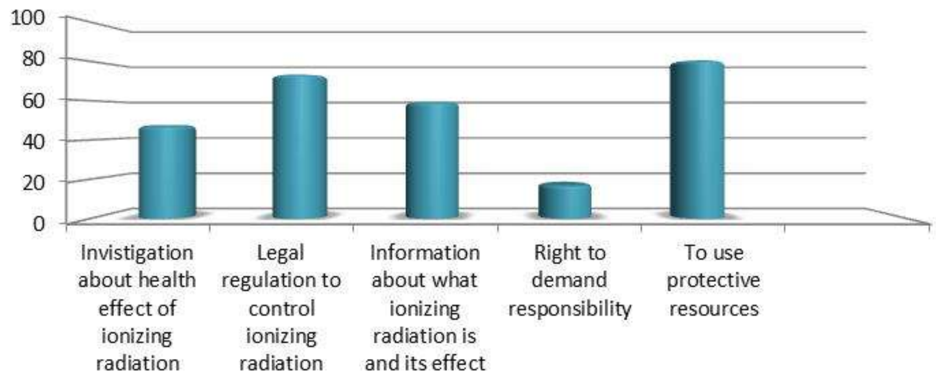

FIG. 6. Different options for feeling safe from ionizing radiation.

7. CONCLUSION

Altogether12 hospitals with 22 X ray rooms in Kathmandu valley were monitored for radiation survey. 96 radiation workers have completed the assessment form. Evaluating the questionnaire, we can say that around 70% of the radiation workers are aware about radiation. Almost all X ray & CT working areas are safe. Personnel monitoring for radiation workers is a big problem. Around 70% of the radiation workers are not monitored for radiation. There is a great need for rules, regulation and radiation act in the field of radiation in medical field. There is no quality control program in all surveyed hospitals, but only a maintenance contract with the company. A QC program should be performed on the X ray equipment regularly, following international protocols. TLD results show that at some centers patients receive unnecessary high dose. The highest reading during the chest procedure is 1.31 mSv and average reading is 0.68 mSv. The doses received during lumbar spine investigations are more scattered with a max value of 11.57 mSv with average dose 3.69 mSv. Hence there must be regular quality control parallel to maintenance program for the X ray equipment at regular intervals. For quality control kV measurement and field verification tests were done. The kV test showed that only 41.67% X ray were within limit. Field verification test shows that more that 90% of the field did not match with the actual field size. There is need for more accurate verification of the quality of the images, and their diagnostic significance, in relation of the dose received. The basic radiation protection principles of Justification and Optimization should be taken into consideration in this period of rapid increase of investigation following the availability of new equipment.

The detailed evaluation of the answers given by the personnel working with radiation might provide good indication about the strategy to adopt in designing a training program, which is very much needed.

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