Study on Radiation Protection Infrastructure of Diagnostic X-Ray Facilities at Habiganj District in Bangladesh

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Abstract: ***X-ray is using as an essential tool for diagnosis and treatment of diseases. In Bangladesh most of the X-ray machines are conventional type at district level but technologically developed X-ray machines are increasing day by day. Radiation protection and safety issues are also becoming a great concern in the field of medical sector due to increasing X-ray facility. In the present study, X-ray installations at Habiganj district in Bangladesh are chosen to analysis the radiation protection infrastructure of 30 diagnostic X-ray facilities. The main objective of this study is to verify the compliance of all regulatory requirements through the analysis of the data regarding radiation protection matters. It has been observed that in 83% facilities, radiation doses are within regulatory limit but most of the X-ray room sizes are below the required value (225ft2), it is matters of concern from regulatory point of view.60% of all X-ray facilities have been found satisfactory performance from radiological safety point of view. Most of the facilities the personal protective equipment is found in satisfactory condition but the thermoluminescence dosimeter (TLD) in the facilities are found below satisfactory level. To strengthen radiation protection infrastructure of all X-ray facilities and to ensure effective regulatory control over the facilities the current study can contribute in near future of Bangladesh.***

Keywords: radiation exposure, competent authority, occupational worker, safety parameters, medical X-ray equipment

1. Introduction

In Bangladesh the radiation generating equipment like X-ray machine, CT-Scanner, Dental, C-arm etc. are using for a wide variety of peaceful purposes in radiological examination and treatment. But with respect to the total population of Bangladesh, the diagnostic X-ray facilities are still inadequate. As a result, X-ray facilities are gradually expanding day by day from city to rural area in Bangladesh on the base of public needs. Radiation protection and safety issues are also becoming a great concern in the field of medical sector due to increasing X-ray facility. The evaluation of all radiological facility is an essential part of the regulatory regime. According to the UNSCEAR, the radiation doses from diagnostic radiology are the largest contribution to the collective dose from all man-made sources of radiation. Before installation of any kind of radiation generating equipment, room design and layout approval is essential from competent authority; name Bangladesh Atomic Energy Regulatory Authority (BAERA) according to national requirements [1, 2]. However, no facility receives such approval from a regulatory body prior to the machine's installation. As a result, X-ray facilities' radiation protection infrastructures have not been appropriately developed to assure radiation safety. Therefore, large modifications are required in order to fulfill the national regulatory requirements [3]. It is important to monitor the status of regulatory compliance requirements during the design stage of an X-ray room. In this connection, good quality machine, adequate personal protective equipment, educated and trained man power, external shielding arrangement on the present structure can play an important role to keep the radiation dose at permissible level for both the occupational worker and general public [1, 4]. To achieve effective, efficient and uniform regulatory control in medical X-ray equipment and installations, it has been realized that radiation protection infrastructure of all X-ray units and installations in the country should be studied explicitly. Regulatory body in Bangladesh has initiated a program to carry out the regulatory inspection and radiation survey of all X-ray units in the country to assess the radiation protection infrastructure and its development. Inspection was performed to take out the regulatory data on X-ray machines in Habiganj district as a part of the program. The current study can contribute significantly to improve Bangladesh's radiation protection infrastructure in the future.

2. Literature Survey

In the present study, a detail assessment is carried out on radiation protection infrastructure in the 30 diagnostic X-ray facilities at Habiganj district in Bangladesh. It has been observed that most of the X-ray machines are of conventional type being used for diagnostic imaging and the quality of service provided by the equipment is definitely poor. The main objective of this study is to verify the compliance of all regulatory requirements by analyzing data on radiation protection matters [1, 5]. During inspection of the facility, it has been observed that most of the X-ray operators are not well educated and have no proper training in the relevant field. Due to the ignorance of the operator the patient may get extra radiation dose leads the patient in serious condition. Medical technologists who have been educated in the relevant field should be appointed to the diagnostic facility in this situation. At the present study, Radiation dose is measured at different relevant places in the facilities. During investigation of the facilities, different safety parameters are measured particularly on the room size, shielding material at the entrance door, control panel, dark room door and thickness of the X-ray room walls. The personal protective equipment particularly availability of the lead apron is found in satisfactory condition of most of the facilities but the thermoluminescence dosimeter (TLD) badge in the facilities are found below satisfactory level. Among the shielding material, lead has been found mostly at the entrance door and control panel barrier of the facilities but its thickness and uniformity are a matter of concern from regulatory point of view. As a result, regulatory control is required to ensure that X-ray equipment is used in a safe manner.

3. Materials and Methods

In order to investigate the radiation protection infrastructure of diagnostic X-ray facilities, 30 facilities were inspected at Habiganj district in Bangladesh. The regulatory body conducts inspections to satisfy itself that the operator is in compliance with the conditions set out. The layout of the X-ray room was drawn with the measurement of length and width of the room, wall thickness, door and control panel shielding condition and its thickness. The position of the X-ray machine, chest stand, control panel, dark room, computed radiography room and surroundings were also mentioned in the layout. During inspection the radiation exposure levels were measured using a portable dose rate meter. Two radiation dose rate meters of Geiger Muller (GM) type were used to make the findings more accurately. These instruments were calibrated at secondary standard dosimetry laboratory (SSDL) of Bangladesh Atomic Energy Commission before using in the inspection. Before starting the dose measurement of the X-ray room, the background radiation dose level was measured. After that dose rate was measured at different location of the X-ray room like control panel (CP), entrance door (ED), dark room (DR), computed radiography (CR) room, patient waiting place, reception place, and additional door or other opening space (if any). The information was also taken during inspection for each X-ray installation such as X-ray machine installation Year, X-ray machine type containing its model, serial no, manufacturer, maximum tube potential (kV), maximum tube current (mA), light beam diaphragm and total tube filtration, number of exposures taken on the average in a day, number of workers involved included radiologist, radiographers, operators and other workers. It has been investigated that the personal dosimetry devices are worn on the appropriate part of the body by designated personnel; records of personal monitoring are maintained and preserved, checking that all individual annual doses are below the annual dose limits and also verified that the appropriate personal protective equipment is available. The surrounding areas of the X-ray room were observed to verify whether the surrounding people are getting exposure or not and also verified whether the public are exposed to radiation. It is also verified whether facility personals are following the working rules and performing their routine tasks accordingly. The presence of warning sign, warning notice and warning signal at the access point of X-ray room was checked. Inspection findings describe the status of X-ray machines, shielding and dose level status, over all working conditions of X-ray installations etc. based on regulatory data of Habiganj district in Bangladesh. The result also shows the comparison study of the present regulatory data with the previous inspection data. The findings of this programme are being used as data base or reference document to enhance the radiation protection infrastructure in the country.

4. Results and Discussion

A total of 30 X-ray units were studied in the Habiganj district in Bangladesh. Among all the X-ray machines, largest numbers of X-ray machines were seen in 250mA.

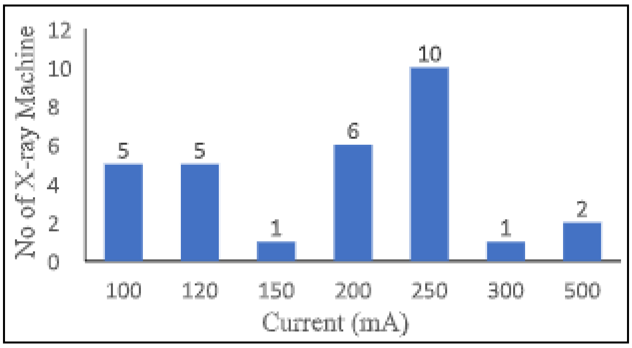

Figure 1: Quantity of X-ray machine with mA

Figure.01 shows a graphical illustration of number of X-ray machine with different current level (mA). Most of the installations use lead and brick as shielding material for control panel of X-ray room. The area of the X-ray room in most of the facilities lies below the standard size ≥21sq. m or 225ft2, it is a matter of concern from shielding point of view. For X-ray facilities shielding analysis of some areas are essential, especially in control panel, outside of the entrance door, where a group of radiation worker may be exposed to a considerable amount of radiation [6]. Due to inadequate room size, it does not permit optimum mobility of the equipment and the staff during radiological examination. In several cases, X-ray rooms are not well planned and designed with the regulatory standards for radiation safety in mind. Because of these, the undesirable exposures of occupational workers, patients and the general public are unavoidable.

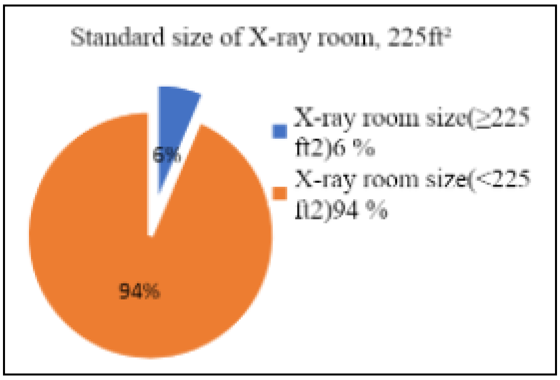

Figure 2: X-ray room size status of Habiganj district

Fig.2 shows the X-ray room size status of Habiganj district where only 6% are standard size and 94% are below standard which requires huge improvement to fulfill the regulatory demand. All X-ray rooms except one have 10" brick wall, which are effective in the protection of X-rays. Most of the facilities radiation dose level was within regulatory limit (10μSv/hr for occupational worker) because the entrance door and control panel barrier were lead and brick shielded.

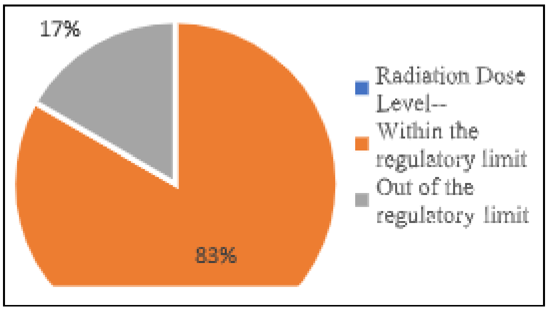

Figure 3: Dose level status of X-ray installations at Habiganj district

Fig.3 shows in 83% facilities radiation doses are within regulatory limit where 17% are out of regulatory limit.

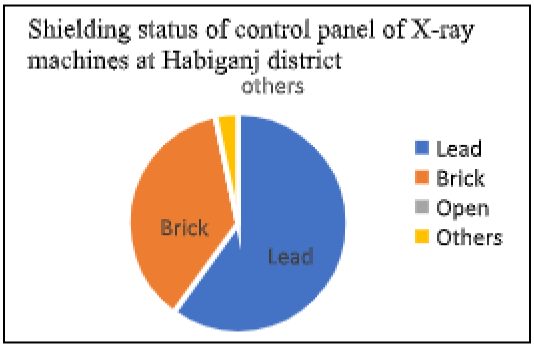

Figure 4: Shielding status of control panel of X-ray machines

Fig.4 indicates the shielding condition of the secondary barrier (Control Panel); lead is most commonly used shielding material in control panels, covering 60% of all installations, while brick is the second most commonly used shielding material in control panel barriers.

The chest stand is sometimes inappropriately located in a manner that the primary beam is directed towards the occupied areas or the dark room where undeveloped films are also stored. In many cases patient waiting areas are not provided properly, sometimes patients and their relatives are made to wait very near to the X-ray room during exposures. Radiation warning signal are rarely displayed, but in most cases radiation caution sign had been displayed. The lead Goggles and lead hand gloves for the operators were not found in any X-ray facilities but lead apron was available in most of the facilities for the protection of radiation worker. Among the 30 installations, only 14 installations of them have TLD-Badge for personal radiation monitoring. The majority of radiation workers are not qualified in terms of radiation safety and protection.

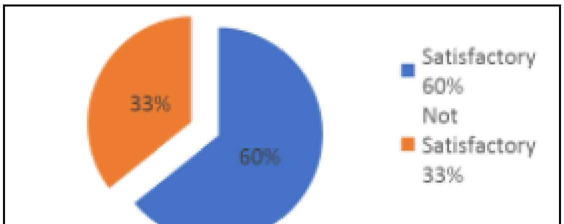

Fig.5: Overall condition of X-ray installations at Habiganj district

Among all inspected installations in Habiganj district, 18 (60%) installations have been found satisfactory performance from radiological safety point of view (Table.1 and Fig.5). The results show that the overall performance of the radiographic X-ray systems is merely satisfactory since only 60% of them have satisfactory performance in compliance with the regulatory requirements. However, the monitoring and surveillance is needed to more improvement of the equipment performance and operational safety in diagnostic X-ray installations. The dose rates observed at some points of interest around the X-ray machines are tabulated in Table 1.

Table 1: Radiation dose levels at some points of interest in and around the X-ray installations at Habiganj district:

Facility Installation Code	Operating condition			Dose rate (μSv/hr)					Overall Assessment
	kV	mA	Time (sec)	Entrance door	Control panel	Additional door	Dark room	Other Location	
HAB (D)-P-63	52	160	0.5	0.2	0.15	NA	NA	0.2 (patient waiting area)	SA
HAB (D)-P-58	65	80	0.5	9.0	7.0	NA	NA	Not Applicable	NS
HAB (D)-P-54	65	100	1.0	10.5	0.5	NA	NA	do	NS
HAB (D)-P-64	60	100	0.5	0.5	0.5	0.6	NA	do	NS
HAB (D)-P-80	65	100	0.6	5.0	0.9	NA	NA	do	NS
HAB (D)-P-59	60	100	1.0	1.0	1.5	NA	NA	do	SA
HAB (D)-P-26	65	150	0.4	0.1	1.0	0.3	NA	0.2 (reception area)	SA
HAB (D)-P-69	60	100	0.32	0.5	0.2	NA	NA	Not Applicable	NS
HAB (D)-P-81	80	100	0.1	0.5	0.4	NA	NA	0.3 (Doctor room)	NS
HAB (D)-P-39	70	150	0.6	7.0	8.0	0.5	NA	0.4 (Corridor)	NS
HAB (D)-P-61	65	150	0.4	0.5	0.1	NA	NA	Not Applicable	SA
HAB (D)-P-76	70	200	0.8	0.5	0.5	NA	NA	do	SA
HAB (D)-P-75	65	160	0.63	0.5	1.0	NA	NA	0.4 (Corridor)	SA
HAB (D)-P-78	65	80	1.0	1.0	5.0	NA	1.0	0.3 (Toilet)	SA
HAB (D)-P-73	50	200	0.8	0.4	0.5	NA	NA	Not Applicable	SA

HAB (D)-P-72	70	150	0.6	10.50	1.2	0.35	NA	1.0 (patient waiting area)	NS
HAB (D)-P-74	80	150	0.4	0.25	0.5	NA	NA	0.25	SA
HAB (D)-P-77	60	80	2.0	0.5	1.0	NA	NA	Not Applicable	SA
HAB (D)-P-65	75	100	0.8	10.4	0.5	NA	0.5	do	SA
HAB (D)-P-18	60	100	0.63	50	1.5	0.70	NA	do	NS
HAB (D)-P-71	78	200	0.8	0.5	1.2	NA	NA	1.0 (CP door)	SA
HAB (D)-P-60	80	150	0.4	0.5	0.5	NA	NA	0.2 (Pathology room)	SA
HAB (D)-P-70	70	100	0.2	0.5	0.3	NA	0.2	Not Applicable	SA
HAB (D)-P-62	60	80	0.6	0.2	0.5	0.30	NA	do	SA
HAB (D)-P-52	65	150	0.2	0.5	8.0	0.45	NA	do	NS
HAB (D)-P-56	70	100	0.8	0.3	0.4	NA	NA	do	SA
HAB (D)-P-55	80	100	1.6	0.2	0.45	0.25	NA	0.6 (Director room)	NS
HAB (D)-P-57	60	100	0.63	8.0	0.5	NA	0.3	Not Applicable	SA
HAB (D)-P-53	80	100	0.8	0.35	0.5	NA	NA	do	SA
HAB (D)-P-66	60	100	1.2	3.0	20	NA	NA	do	NS

[ED=Entrance door; CP=Control panel; DR= Dark room; OR= Other room; BR= Background Radiation level (0.20-0.30µSv/hr), NA= Not Available; NR= Not recorded; SA=Satisfactory; NS=Not Satisfactory; NA=Not Available; OXR= Outside of x-ray room]

From table-1 it has been observed that dose rates at few locations are much higher than permissible dose limit (10µSv/hr) for occupational workers**.** Among 30 facilities, only 05 facilities the radiation dose level was found beyond regulatory limit. The dose rates recorded at the ED were found higher (50µSv/hr) in one facility of Habiganj district. During data collection the background radiation level was found to be from 0.20 to 0.25 µSv/hr in the X-ray installations.

From the data analysis, it is found that nearly one third installations are complied with the required standards. The Quality Assurance (QA) program, dosimetry and calibration services were not present in any one of the X-ray installations. In 30 facilities, among the 37 radiographers only 05 radiographers of them have Diploma in Medical Technology which obviously display the poor scenario of academic qualification of medical technologists. Most of the technologists are becoming trained through their professional work. Some of them have taken short training on radiation protection from the Bangladesh Atomic Energy Regulatory Authority (BAERA). Most of the installations need to improve. Machine room area requires to increase and square in shape in most of the facility and machine should be positioned in the centre of the room. Nonetheless, if an installation follows the general operating rules and carry out some improvement, the installations may be allowed to function with the required license to be obtained from the Bangladesh Atomic Energy Regulatory Authority (BAERA).

5. Conclusion

X-ray is an ionizing radiation and radiation exposure increases incidence rate of fatal cancer to the exposed persons. Diagnostic X-ray is an essential component of health care. The diagnostic X-ray installations also have potential risks of causing unnecessary radiation exposures to the occupational workers, patients and public. Therefore, adequate safety for X-ray generating equipment is required to ensure high image quality as well as protection to the patients, workers and public. The present radiation protection infrastructure of the facilities requires considerable improvement to fulfill the requirements of national and international regulations relating radiation safety. In the present study the deficiency of radiation shielding arrangement have been identified for taking appropriate initiatives to develop radiation protection infrastructure following regulatory guideline and appoint educated and professionally sound manpower and ensuring availability of radiation monitoring equipment. To avoid unnecessary radiation exposure to the workers, patients and the public, it is essential to comply with the regulatory requirements stipulated by BAERA. The responsibility for ensuring radiation safety of diagnostic X-ray is mainly to the facility personnel those are involved with the radiological activities. As there is legal authority in the country through the promulgation of BAER Act-2012 and NSRC Rules-1997, it is possible to develop the radiation protection infrastructure in X-ray facilities more in future with the proper implementation of this Act and Rules. Regulatory body will provide proper guidance to ensure radiation safety of X-ray installations and also verify that the facility ensured the radiation safety according to the regulatory requirements. In order to strengthen radiation protection infrastructure of all X-ray facilities and to ensure effective regulatory control on all the medical X-ray installations, both regulatory body and user should function more actively.

6. Future Scope

Accumulating all regulatory data, inspection reports with some recommendations on improvement of radiation protection infrastructure were generated and provided to the respective facilities for infrastructure development relating to radiation safety according to national regulations. There is an opportunity to re-inspect the facilities from the regulatory body in the future to assess whether the facilities fulfilled the regulatory requirements or any changes happened to the facilities regarding radiation safety matter. Re-inspection data can be analyzed for further improvement of the facilities. In order to accurately complete all findings related to radiation safety and protection in all areas, a comprehensive study with a large number of diagnostic X-ray facilities is required. However due to shortage of manpower and lack of logistic support from the regulatory body it is somewhat challenging to move forwards with the study.

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