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Radiation Safety Awareness and Practice in Sudanese Medical Facilities: A Descriptive

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Abstract: ***Despite the recent wide radiation applications in medicine, it can be hazardous if not properly handled. The aims of this study were to determine radiographers' awareness and performance about radiation safety in Sudanese governmental and private medical facilities located at Khartoum State, Sudan. In addition, to assess the work place safety requirements in Sudanese medical facilities from the radiographer point of view. A descriptive cross section study was performed in six governmental and private hospitals with a simple random sample of 50 radiographers working in them. Study tool was a questionnaire distributed to radiographers to collect data. Results showed that radiographers within Khartoum state showed a good knowledge of radiation hazards and protection. However, adherence to radiation protection practices among these radiographers was poor. There is inadequate radiation protection devices (ex. FBDs availability was only 12%) and monitoring (ex. environmental monitoring availability was only 38%) in both functional government and private hospitals. There are radiation accidents due to overexposure as injuries, abortion and sickness cases. The study recommended conducting continuous in service training for radiology staff at all levels about radiation protection and safety. Also disseminate the culture of wearing personal protective equipment (PPE) and all possible safety measures including the equipments for measuring radiation. Radiographers in Khartoum, Sudan should embrace current trends in radiation protection and make more concerted efforts to apply their knowledge in protecting themselves and patients from harmful effects of ionizing radiation.***

Keywords: Radiation protection, Radiation safety, Khartoum Sudan, Medicine

1. Introduction

Despite the recent wide radiation applications in medicine, it can be hazardous if not properly handled. A careful balance between the benefits of enhancing human health, and the risks related to the radiation exposure of radiographers, patients, and the public, has to be involved in the practice of diagnostic and interventional radiation. X-rays have the potential for damaging healthy cells and tissues. After interaction of ionizing radiation with biological tissues through various mechanisms, the ions caused by such interactions can affect normal biological processes. Improper protection against high exposures of ionizing radiation can lead to death, cancer, skin burn, cataract, and radiation infertility (deterministic effects) (Adejumo, et al., 2012) [1]. In addition, although the low dose of radiation exposure may cause no observable damage, the probability of chromosomal damage in the germ cells, with the consequence of mutations giving rise to genetic damages (stochastic effects), can make such doses significant for large populations. Accordingly, the need for radiation protection exists, in all medical facilities and for all radiation equipment types.

Radiation protection is the science and art of protecting people and the environment from the harmful effects of ionizing radiation. It is also described as all activities directed towards minimizing radiation exposure of patients and personnel during x-ray exposure (Johnston et al., 2011) [2]. The objective of radiation protection is to protect individuals, and their generations against the potential risks of ionizing radiation (Eze and Okaro, 2004) [3]. Fundamental principles of radiation protection are justification, optimization and time. Based on the understanding of these fundamental principles, exposing only an individual (s) who should derive maximum benefits from such exposures to ionizing radiation (justification), making sure that radiation doses as result of medical exposures are only enough to achieve needed diagnoses (optimization) and reducing the time of exposure to sources of ionizing radiation are means of achieving radiation protection. Consequently, uses of immobilizers, positioning aids, beam size (x-ray field) limiting devices, the type and state of x-ray machines are important factors in radiation protection. Furthermore, Fatahi- Asl et al., 2013[4] reported that availability of installed radiation protection instruments such as area radiation monitors, air borne contamination monitors and personnel exit monitors; and portable instruments such survey meters, lead rubber shields and personnel dosimeters for staff and work place monitoring are also essential. Radiation protection measures also include periodic quality assurance checks on the x-ray machine (s).

The International Commission on Radiological Protection (ICRP) recommended a system for limiting the doses received by radiation-exposed workers (ICRP, 2012) [5]. Its report addresses radiation safety practices in industrial and medical institution, control of radionuclide in the environment, protection of the public and assessment of radiation risk. A key part of managing radiation safety is through education. Every person involved in radiation usage needs to know what radiation is and how to handle it because the number of diagnostic radiology procedures performed continues to grow yearly. With this growth, there should be concern for practice radiation safety (Adejumo, et al., 2012) [1].

Many factors can increase the patients' radiation dose such as disproportionate radiation field, long periods of radiation, close range of radiation source to the body, and avoiding use of lead shielding. Therefore, radiographers, through using their knowledge of radiation safety protection, can minimize absorption of radiation in both themselves as well as patients, while maintaining the diagnostic value of the

radiographic image (Rahimi et al., 2007) [6]. Proper use of personal protective equipment and observing the instructions and regulations for protection against ionizing radiation can greatly reduce unnecessary exposure. Therefore radiographers' knowledge of such standards and observances can play an important role in protection against radiation (Bezanjani, 2009) [7].

In Sudan, many public and private hospitals in Khartum State. The need to improve profits and conserve funds, lead to different types of practices that are detrimental to health. Some junior staff are employed with little formal education and they function with the little in-service training and experience. There is indistinctive use of X-rays and other investigative facilities with the aim of generating funds. Non-specialists who open up X-ray centers for profit-making often pay less attention to radiation protection which is viewed as money wasting leading to poor standard of radiation protection to the public and the radiation workers. (Eze, et al, 2011) [8].

There are a few reported studies on the level of radiation safety awareness amongst radiation staffs in other countries (Soye and Paterson, 2008) [9] (Lee et al, 2004) [10]. However, the level of knowledge and radiation safety awareness among radiographers in Sudan are not known.

Objectives of Study

The present study was carried out to determine radiographers' awareness and performance about radiation safety in Sudanese governmental and private medical facilities located at Khatum State, Sudan. In addition, to assess the work place safety requirements in Sudanese medical facilities.

2. Material and Methods

This study was a descriptive cross-sectional study which was carried out during April to August 2014. Simple random sampling method was used to select six hospitals with the largest concentration of radiographers in Khartoum state. Fifty radiographers (n = 50) who gave oral consents to participate in the study were recruited. The randomly selected hospitals were Al Khartom Teaching Hospital (ATH), Bahary Teaching Hospital (BTH), Aum Dorman Teaching Hospital (ADTH), Fedail Hospital (FH), Alzytona Hospital (AlzH), and Royal Care Hospital (RCH).The first three hospitals are government owned tertiary health institutions, while the rest are privately owned. Only radiographers in the six facilities who were licensed by radiographers' Sudanese Medical Councel (SMC), and who were practicing conventional radiography were included in this study. Radiology students and very senior radiographers who were engaged in administrative duties were excluded.

The study tool used was a semi-structured, self-administered questionnaire which was adopted from previous studies (Yunus et al., 2014) [11] and modified by the researchers for collecting data from the fifty radiographers. It included three parts, the first was demographic data as age, sex, and experience in years. The second part was related to availability of radiation devices in the x ray facility such as personal and environmental monitoring records, presence of each of lead rubber aprons, film badge dosimeters (FBD), gonadal shield, written radiation protection policy, safety warning signs, lead lining of walls &doors, Presence of out of date x-ray machines still under use, and presence of any imported used equipment within the facility. The third part concerned the awareness of radiographers about radiation hazards, radiation safety, radiation safety standard, important radiation safety, and wearing of PPE during any imaging procedure. Also it included questions related to accidents occurrence, and their causes from the radiographer point of view.

Statistical Analysis

The collected data were coded, analyzed and tabulated using Statistical Package for Social Science (SPSS version 16.0) for windows. Descriptive statistics was used to present frequency of different parameters.

3. Results

The distribution of studied sample of radiographers by type of hospitals is shown in table1.More than half of radiographers (58%) were from Governmental hospitals, while 42% were from private ones. The demographic characteristics of respondents who completed questionnaires are given in table2. Majority of studied radiographers were male (70%), within age group 30-<40 years (42%), and have experience of 5-<10 years (38%).

Table 3 highlighted the availability of radiation safety devices (from the radiographer's point of view) in governmental and private x-ray facilities in Khartoum State, Sudan. Only (20.7 %) of radiographers working at governmental hospitals mentioned that their facilities have personnel and environmental monitoring recodes, while approximately 80% are not monitored. Among radiographers working at the private hospitals, thirteen (61.9%) mentioned that their facilities have personnel and environmental monitoring recodes while eight (38.1%) are not monitored. All the hospitals either governmental or private have lead rubber aprons. All the governmental hospitals had gonadal shield although none is using them on a routine basis. Only eleven (52.4%) private hospitals has gonadal shield. There is also only limited lead lining of doors and walls in governmental hospitals as mentioned by seven (24.1%) radiographers working within them, and by 14.3% in private ones, while no lead lining are used in 22 (75.9%) in governmental hospitals and also in 18 (85.7%) in private ones. The lowest availability of radiation safety devices were in both presence of FBD (6.9%), and presence of safety written policy (6.9%) in governmental hospitals. Although slightly higher percentages, a similar pattern was observed in private hospitals regarding the previous two parameters (19%), and (23.8%) respectively. In addition it is worth noting that 43.3% & 58.6% of governmental hospitals and 61.9% & 71.4% of private ones were used out of date x-ray machines and imported used radiation equipment respectively.

Table4 and Fig.1 showed the response of radiographers to radiation safety compliance. It seems that most

radiographers have good awareness to radiation hazards (98%), radiation safety (96%), radiation safety standards (90%), and importance of radiation safety (100%). However, only 38% of them wear PPE during any imaging procedure.

Table5 demonstrated accidents occurrence and its causes from radiographers point of view. 48% of radiographers said that radiation accidents occurred. Their types were injuries and other types like headache, muscles and joints pain, also abortion cases was reported as a type of radiation accidents. We studied the causes of accidents among 24 radiographers who mentioned that accidents occurred. Breach of safety & security requirements (87.5%), mishandling of sealed sources (87.5%) and human error (70.8%) were the main accident causes.

Table 1: Distribution of studied sample of radiographers by type of hospitals

Hospital Type	N0.	%
Governmental Hospitals		
ATH	13	26
BTH	9	18
OTH	7	14
Private Hospitals		
Fedail Hospital	5	10
Alzytonah Hospital	6	12
Royal Care Hospital	10	20
Total	50	100

ATH: AlKhartoum Teaching Hospital, BTH: Bahary Teaching Hospital
OTH: Oum Dorman Teaching Hospital.

Table 2: Demographic characters of 50 studied radiographers

Demographic data	N0.	%
Age groups (years)		
20 -	16	32
30-	21	42
40 and more	13	26
Gender		
Male	35	70
Female	15	30
Experience:		
< 5 years	10	20
5 -	19	38
10 -	11	22
15 and more years	10	20
Total	50	100

Table 3: Assessment of the work place safety requirements, from the radiographer's point of view, in governmental and private hospitals in Khartoum State, Sudan

Parameters	Governmental No. %	Private No. %	Total No. %
Personal monitoring records (yes)	6 20.7%	13 61.9%	19 38%
Environmental monitoring records (yes)	6 20.7%	13 61.9%	19 38%
Presence of lead rubber aprons (yes)	29 100%	21 100%	50 100%
Presence of FBD (yes)	2 6.9%	4 19%	6 12%
Presence of gonadal shield (yes)	29 100%	11 52.4%	40 80%
Presence of safety written policy (yes)	2 6.9%	5 23.8%	7 14%
Lead plaster/lead lining of walls and doors (yes)	7 24.1%	3 14.3%	10 20%
Safety warning signs (yes)	19 65.5%	13 61.9%	32 64 %
Presence of out of date x-ray machines still under use (yes)	14 43.3%	13 61.9%	27 54%
Presence of any imported used radiation equipment (yes)	17 58.6%	15 71.4%	32 64%
Total	29 100%	21 100%	50 100%

Table 4: Response of radiographers to radiation safety compliance

Description	Yes No. %	No No. %	Total No. %
Awareness of radiation hazards	49 98%	1 2%	50 100%
Awareness of radiation safety	48 96%	2 4%	50 100%
Awareness of radiation safety standards	45 90%	5 10%	50 100%
Importance of radiation safety	50 100%	0 0	50 100%
Wearing PPE during any imaging procedure	19 (38%)	31 62%	50 100%

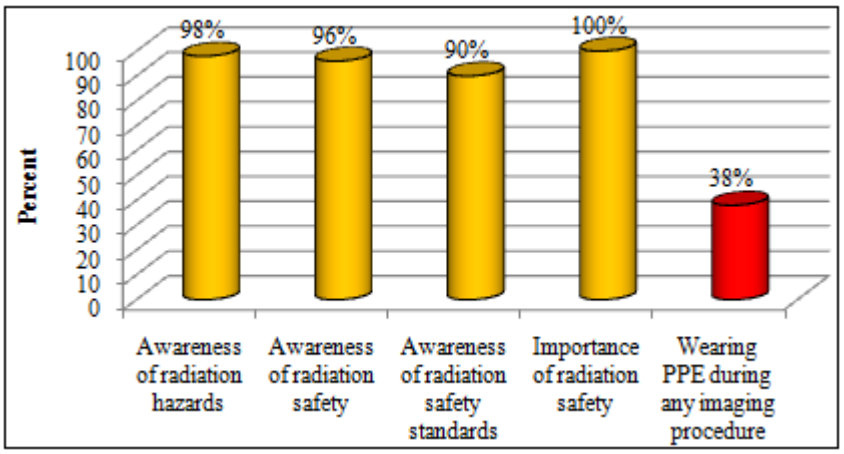

Figure 1: Response of radiographers to radiation safety compliance

Table 5: Accidents occurrence and its causes from radiographer's point of view

Parameters	N0.	%
Accidence occurrence:		
Yes	24	48%
No	26	52%
Types of accidents:		
Injuries	15	62.5%
Death	0	0
Others	9	37.5%
Subtotal	24	100%
Causes of accidents:		
1-Breach of safety or security requirements:		
Yes	21	87.5%
No	3	12.5%
2- Mishandling of sealed sources:		
Yes	21	87.5%
No	3	12.5%
3- Human error or inappropriate calibration procedures:		
Yes	17	70.8%
No	7	29.2%
Subtotal	24	100%

4. Discussion

The implementation of radiation protection for patients, radiographers, and public is inevitable, and is mainly a vital responsibility of every radiation personnel either manager or worker. The safety of all radiological and medical imaging centers in Sudan is controlled by the Sudanese Atomic Energy Commission standards (SAEC), these radiation centers must meet compliance or otherwise they would face penalty. Safety Standards can only be implemented through an effective radiation safety infrastructure. The results of this study reveals low personal and environmental radiation monitoring by hospitals in Khartoum State as only (20.7 %) of radiographers working at governmental hospitals mentioned that their facilities have personnel and environmental monitoring recodes, while approximately 80% are not monitored. Among radiographers working at the private hospitals, thirteen (61.9%) mentioned that their facilities have personnel and environmental monitoring recodes while eight (38.1%) are not monitored. These results are similar to Eze et al., 2011[8] study, in Nigeria, who reported that there is inadequate radiation protection and monitoring in most of the functional government and private X-ray facilities in Edo State, Nigeria. Also, it was noticed during field visits in this study, that there is poor recordkeeping in both private and government hospitals, (Ameh and Shehu, 2002) [12], but this is worse in private hospitals, with limited space and lack of reference to old records. This means if old x ray sheet lost repeat x ray will be done with more radiation exposure for both patients and radiographers.

The personal protection requirements of workers in the radiated area is one of the basics preventive measures in all health care & radiation safety policies, but Sudanese radiographers still suffer from carelessness about these basics. In addition the governmental facilities have a poor work environment regarding to safety & security system. This study highlighted that the lowest availability of radiation safety devices were presence of FBD (6.9%), and presence of safety written policy (6.9%), in governmental hospitals. Although slightly higher percentages, a similar pattern was observed in private hospitals regarding the previous two parameters (19%) and (23.8%) respectively. Also Sudanese have a big problem about equipments; many of them don't meet neither international nor Sudanese standards and still under use. Although, out of date equipment includes equipments which needs to be replaced, discarded or need maintenance, it is worth noting that, in this study, 43.3% of governmental hospitals and 61.9% of private ones were used out of date x-ray machines. Moreover, it was observed that imported used equipments took the major part of equipments used in governmental and private facilities in Khartoum state (58.6% and 71.4% respectively). Safety of these machines is questioned in addition to illegality of usage. Used machines could seem to be working fine, but its working history remains unknown which introduce many problems especially for diagnostic equipments. Also the used equipment loses its responsibility rights from the manufacturer or distributor who ensures that the equipment conforms to the requirements of the regulation. Our result was similar to that reported by Eze et al, 2011[8]

Shielding in x-ray facilities is one of the primary prevention activities, to reduce the unnecessary exposure of staff and public to levels considered to meet the ALARA ("As Low as Reasonable Achievable") condition.. Shielding must be provided so that the calculated radiation doses will be less than 0.5 mSv/annum for a person occupationally exposed

and 0.05 mSv/annum for a member of the public (IAEA, 2008) [13]. Unfortunately, this study revealed the poor shielding lead plaster/lead lining of walls and doors (20%), so x-ray rooms are not protected as it must be in standards. There was a good availability of lead rubber aprons in governmental and private hospitals (100% for each). Use of lead aprons creates an average of 75% to 80% protection of the red marrow (Devod, 2000) [14]. In addition, gonadal shield were available in a 100% percentage in governmental hospitals, and a lower availability of it in private hospitals (52.4%).However, radiographers were poorly use these safety devices (only 38% use them).

Safety warning signs are an important restriction that controls access to x-ray areas in order to alert workers about the area conditions and requirements, practically by taking a look to the obtained percentages; 64 % of studied radiographers mentioned the availability of Safety warning signs in their working hospitals. In the field of radiation, a dosimeter is a measuring device used to measure radiation dose, and it cannot be applied as a radiation protection tool. To measure an occupational radiation, it is well known that the Sudanese worked policy depends on a committee from the (SAEC) that have a visit every a considerable time, to the hospital, to ensure that the occupational dose is within the reasonable limit, but no personal dosimeters provided to workers as a safety regulations mentioned "Personal dosimeters must be worn by all x-ray workers while on duty." In this study only 12% of radiographers mentioned that FBD are available in their work places.

This study reported that most Sudanese radiographers, working at Khartoum, have good awareness to radiation hazards (98%), radiation safety (96%), radiation safety standards (90%), and importance of radiation safety (100%). This result is better than what was reported in a similar study in Uganda which found knowledge of radiation protection issues among radiographers in that country to be poor (Muty abule et al.2002) [15]. However, only 38% of them wear PPE during any imaging procedure. This may be due to the poor availability of both personal and environmental safety devices in their work place, or it may be due to their carelessness to wear PPE during any imaging procedure. However, this result is surprising and alarming. It should be strongly recommended them to improve their knowledge around importance of wearing PPE, and update them through growing their expertise.

Over the last three decades, at least 3000 patients have been affected by radiotherapy accidents (Holmberg, 2009) [16]. In this study, 48% of radiographers said that radiation accidents occurred. Accidents types were ; injuries and other types like headache, muscles and joints pain, also abortion cases was reported as a type of radiation accidents. The main reasons for these accidents were a breach of safety & security requirements (87.5%), mishandling of sealed sources (87.5%) and due to human error (70.8%). These accidents may be due to lack of radiographers awareness, lack of qualified well-trained staff, and shortage of facilities resources

Probability and magnitude of accidents could be reduced by through a particular safety strategy supervised by the relevant service manager which is a part of his/her responsibilities, that is achieved by ensuring that no radiation exposures are 'wasted' because of faulty or inappropriately used equipment. This responsibility includes careful attention to equipment maintenance, quality assurance (including early fault reporting) and all relevant aspects of staff training. All operators should be aware at all times that they have a responsibility to try to avoid 'wasted' exposures. Levels of over-exposure requiring external reporting are subject to national review. Issues of possible 'over-exposure' should be reviewed initially and urgently with the radiation protection department. Limitations of the study include the uncooperativeness of some radiographers in filling out the questionnaires and a need to conduct the study on a larger scale to include all geographic areas of Sudan.

5. Conclusion

Radiographers within Khartoum state showed a good knowledge of radiation hazards and protection. However, adherence to radiation protection practices among these radiographers was poor. There is inadequate radiation protection devices and monitoring in most of the functional government and private hospitals in Khartoum, Sudan. There are radiation accidents due to overexposure as; injuries, abortion and sickness cases. Radiographers in Khatoum, Sudan should embrace current trends in radiation protection and make more concerted efforts to apply their knowledge in protecting themselves and patients from harmful effects of ionizing radiation.

6. Recommendations

The study recommends the following:

1. All persons working with a radiation source should receive the appropriate in service training for the use of that radiation source and possess the appropriate qualifications for operation of the equipment.
2. Disseminating the culture of using PPE and all safety gadgets and highlighting the importance of them.
3. Introduce Health Safety& Environment as a major subject in medical and paramedical undergraduate and post graduate students.
4. The safety committee's role should be more than monitoring the occupational dose, and there periodic visits duties should include general updating revisions to all most recent safety procedures for staff and patients.
5. Each facility should develop an audit program aimed to include specific attention to the justification of ionizing radiation procedures and to the radiation doses from them.
6. Management units should be ultimately responsible to ensure that all aspects of safe work is being strictly adhered to and that the equipment and the facilities in which such equipment is installed and used meets all applicable radiation safety standards. Also installed equipments in medical facilities must pass equipment acceptance test
7. Continuing education and professional developed programs chances should be provided to staff members in order to keep skills and knowledge up to date to achieve high standard work.

8. Enforcement of laws especially those referred to the equipments compliance and legality. All equipments must conform requirements and regulations and meet federal standards.

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