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Knowledge, Attitude and Practice of Sudanese Orthopaedic Registrars Towards Intra-Operative Radiation Protection

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Abstract

Orthopaedic surgeons are at higher and increasing risk of radiation exposureduring fluoroscopically guided procedures. However, this risk can be decreased by adherence to standard radiation protection precautions and by better knowledge and practice during exposure. To assess the level of Knowledge , attitudes , and practice towards intra-operative radiation protection among the rotating Sudanese orthopaedic surgery registrars . Knowledge Attitude and Practice Survey:The questionnaire was handed to all (67) previously identified orthopaedic surgery registrars enrolled in Sudan Medical Specialization Board training program . Questionnaires were filled . Most of orthopaedic surgery trainees did not adhere to radiation protection principles .Only fifteen (24.6%) , twelve (19.7%), and seven registrars (11.5%) have accepted level of knowledge, attitude, and practice towards intra-operative radiation protection respectively after categorization according to their achieved scores. There is a significant relationship between radiation protection workshop attendance and level of knowledge , attitude ; and practice with P value 0.0003 , 0.004 , and 0.0000 respectively . only 6.6% of the registrars attend a workshop of this concern . Also those who read a literature about radiation protection have a better knowledge with P value 0.0000 , attitude with P value 0.0000 . Their practice to lesser extent better than those not reading an article regarding radiation protection at all with P value 0.1010 .Only 19.7% of the registrars who read such literature .

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This study showed low levels of Knowledge , Attitude , and Practices among the Sudanese orthopaedic surgery registrars in protecting themselves against intra-operative radiation protection .Most of the registrars neither read about radiation protection nor attended a workshop .

Key words: Intra-Operative; Radiation; Protection.

1. Introduction

In the early days of radiology, only fluoroscopy was performed for the detection of fractures and the assessment of subsequent therapy. It was recognized soon after discovery of x-rays that exposure to large amounts of ionizing radiation can produce deleterious effects on the human body. Within the first months after the discovery of the x- ray ,some investigators noted skin changes due to the effects of too much exposure . These changes were most evident in the hand because the radiographer commonly used his own hand to gauge the penetrating power of the tube.In Germany, the first radiation burn of a hand was reported on 1896 of an engineer who used his left hand as the test object for tube testing [1]. A major advantage of radiology was that it could be performed through an ordinary plaster cast without the need to remove a splint. This technique also significantly altered the concept of fracture healing [2] However the first real image intensifier, marketed for the first time in 1952[3] in Germany . The equipment consists of the Z-shaped support, the single-tank transformer and tube with attached cone, and on the other arm of the U an image intensifier with vidicontube. The television monitor could be pushed around on its own casters. More recently, because of increased scientific knowledge and wide spread use of radiation, additional attentions has been directed to the possible effects of lower levels of radiation on future generations. Various scientific bodies have made recommendations to limit the irradiation of the human body. Probably the oldest of such scientific bodies are the International Commission on Radiological Protection (ICRP) and the U.S. National Committee on Radiation Protection and Measurements (NCRP). Orthopaedic surgeons and staff are exposed to radiation during a variety of procedures. In general, orthopaedic staff are exposed to both direct and scattered radiation during procedures.Fluoroscopy is an invaluable tool in orthopaedic surgery and its use has increased significantly over the last twenty-five years. It helps to reduce operative time, increases accuracy of surgery and reduces the size of the operative field(4) thus minimizing patient morbidity but the main disadvantage is radiation exposure.The key principle of the use of ionizing radiation is to keep the dose to as low as reasonably achievable. Over the past few decades, orthopaedic surgery procedures using fluoroscopy screening has increased [4-6].Reports indicate that among the procedures that require fluoroscopic monitoring, closed locked femoral nailing is responsible for a high level of scattered radiation exposure among primary surgeons [5]. According to recent reports, improvements in image intensification technology have led to a reduction in the fluoroscopic time required for similar procedures [7]. Since the introduction of mini C-arm devices, fluoroscopic imaging is now routinely used in treating fractures in the emergency room and for outpatient and surgical orthopaedic procedures [6]. The cavalier use of fluoroscopic equipment by orthopaedic surgeons (for example, direct handling of the tube, placing hands directly in the field during operation of the machine) clearly breaches radiation safety guidelines [5]. Biplanar fluoroscopy, or the use of one fluoroscopic unit in two planes, is necessary during certain procedures. This is to monitor and prevent the leakage of polymethylmethacrylate outside the confines of the vertebrae and often requires the use of significant amount of ionizing radiation [8]. The International Commission on Radiological Protection [18] has established the standards for radiation protection including the dosage limits. The maximum annual permissible upper dose limit is 20 mSv for the body, 150 mSv for thyroid and eyes, and 500 mSv for hands (International guidelines, ICRP). However, the dose limit for non classified staff (for example, orthopaedic surgeons) is only 30% of these limits (that is,150 mSv for hands) [9]. The secondary (scattered radiation) dose distribution around the patient is non-uniform and does not exactly follow the inverse law as in the case of a point source and that a large number of dosimeters should be worn by personnel to record the dose absorbed by various body parts like eyes (forehead), (neck) thyroid and fingers or hands.It is suggested that dosimeters should be located under the lead apron (for whole body dose estimation), outside the apron at shoulder level, on the thyroid protector and at the hand [10]. In many situations, the effective whole body radiation dose is only a fraction of the dose to a single organ or tissue [11] . In such cases, the individual organs become the critical factors in the assessment of radiation hazards [12]. Orthopaedic surgeons face a greater risk of radiation exposure to the hands than radiologists and cardiologists [13]. Most of the studies on radiation exposure to healthcare workers (HCWs) are confined to whole body exposure. The source of radiation may come directly from the primary beam or indirectly from scattered radiation [9]. The hands, eyes and thyroid glands are more susceptible to radiation exposure among medical staff due to their proximity to primary radiation.

1.1 hazards of radiation

The number of prolonged fluoroscopic procedures has increased significantly over the last decade due to the push for minimally invasive procedures and improvements in technology. The use of this technique has been adopted by nearly every medical discipline, experiencing tremendous usage growth in emergency room and in orthopaedic, coronary or vascular procedures, resulting in an increased occupational risk of radiation exposure to the surgeon and other personnel in the proximity of the procedure [15]. Orthopaedic surgeons use intra-operative imaging much more often than other surgical specialists, and thus, are at higher risk for radiation exposure. In addition, orthopedic surgeons must often remain near the x-ray beam and cannot distance themselves to reduce their exposure to radiation [14]. During any orthopaedic procedure, the theatre staff is exposed to three types of radiation, the primary radiation coming from the x-ray tube, the secondary or “scatter radiation” which is the radiation reflected off the patient and the operating table and the background radiation originating from the surrounding normal objects. Scattered radiation is the radiation that changes direction during its passage through a substance. When x-rays interact in a patient, many are scattered in random directions from the exposed volume of the patient. In general, thick, heavy parts of the body, such as the thigh, the hip or the abdomen will produce higher levels of scattered radiation than thin parts such as the hand or the arm [14]. During medical procedures, the patient is the primary scattering object and this type of radiation is the principal source of exposure to personnel during fluoroscopic procedures. Ionising radiation, especially fluoroscopy, is potentially harmful with the risk of long term effects due to the cumulative effect of low dose exposure over many years. The effects of radiation exposure fall into two categories stochastic and non stochastic (deterministic effects). Stochastic effects are the result of chromosome damage. In somatic cells, they typically manifest as cancer; in germ cells, as genetic defects in offspring [17]. Many radiation-induced effects occur when change in a single cell is sufficient to initiate biological processes such as the development of cancer. These effects are called stochastic and no known threshold dose exists. The likelihood of inducing the effect increases with dose and may differ among individuals. Such radiation risks include cancers of the blood, bone, lung, parotid gland, and other organs, including the skin [19]. Severity is unrelated to radiation dose. However, higher doses increase the probability that stochastic effects will occur. In contrast, non stochastic effects require a threshold dose. This dose differs between individuals and the magnitude of effects increases with higher doses. Deterministic effects are those for which a minimum number of cells must be affected above a threshold before a biological response is seen. Cataracts or radiation induced erythema and necrosis are examples of deterministic radiation effects. As the dose increases above the threshold, the likelihood of seeing the effect and the severity of the effect increases. If the dose is sufficient, there is a 100 per cent certainty the effect will be induced [19]. Nonstochastic effects typically present within hours or days of exposure and can include erythema, burns, sterility, radiation sickness, and even death; doses high enough to cause death are not typically encountered in the operating room. If the threshold is not reached, cellular damage is repaired, and cumulative effects or long term sequelae are prevented [20] . The radiation sensitivity of a tissue is proportional to the rate of proliferation of its cells and inversely proportional to the degree of cell differentiation. Biological effects are greatest with rapidly growing tissues such as epithelium, bone, blood, gonads, thyroid and fetus. Some effects are cumulative. Studies of people exposed to high doses of radiation have shown that there is a risk of cancer induction associated with high doses. The specific types of cancers associated with radiation exposure include leukemia, multiple myeloma, breast cancer, thyroid cancer, lung cancer, and skin cancer. Radiation induced cancers may take 10-15years or more to appear. There may be a risk of cancer at low doses as well [5]. Exposure to radiation over many years promotes the development of thyroid carcinoma [22].

1.2 Biological Effects of Ionizing Radiation

Radiation can be defined simply as energetic particles or waves traveling through space. Natural radiation sources, including cosmic rays and terrestrial radon gas, account for approximately85% of the exposure to humans [24]. The remaining exposure comes primarily from medical radiography [25]. Natural sources account for an average annual exposure of approximately 0.125 radiation absorbed doses (rad) [25]. As a relative comparison, asingle anterior-posterior chest radiograph carries an exposure of 0.025 rad [14, 25]. Fluoroscopy is of greater concern, as the average direct exposure dose per minute can range between 0.4–4.0 rad [14]. In contrast, ionizing radiation specifically refers to radiation waves carrying enough energy to remove electrons from atoms or molecules, thereby generating excessive free radicals capable of inducing cellular damage [18].This damage increases with the energy of the radiation wave and with higher frequency of exposure, limiting the potential for cell recovery [18]. However, ionizing radiation remains harmful even at relatively low levels [27]. Morphological and functional damage has been observed in some cells dosed with as little as 0.001 rad [27]. Cellular damage from ionizing radiation has been reported for the skin, eyes, gonads, and blood, with the most important long-term concern being cytogenetic and chromosomal damage resulting in increased risk of carcinogenesis [28].

1.3 Processes of Radiation Damage: [18,27]

Physical: energy absorption & ionization (direct damage) Physicochemical interaction of ions & molecules, formation of free radicals (indirect damage). Chemicals: interaction of free radicals with molecules, cells &DNA.

Biological/physiological: cell death, change in genetic data in cells, mutations, cancer.

1.4.Direct Action Damage:

• The radiation interactsdirectlywith the critical target in the cell.

• The interactions lead to the chain of physico-chemical events that will produce the biological damage.

Indirect Action Damage:

• The radiation interacts indirectly with other molecules, 80% water. This will produce free radicals that damage the target molecule chemically.

Radiation Injury to DNA

The most important damage is done to the DNA molecule:

1. Base pair deletion.

2. Cross-linking injuries.

3. Single Strand Break.

4. Double Strand Break.

5. Multiple (complex) lesions.

Fate of Irradiated Cells:

1. No effect.

2. Division delay.

3. Apoptosis: cell death before it can divide.

4. Reproductive Failure: cell death when attempting mitosis.

5. Genomic Instability: delayed reproductive failure.

6. Mutation: cells contains mutation in genome.

7. Transformation: mutation leads to carcinogenesis.

8. Bystander Effects: damaged cell induces damage in surrounding ones.

9. Adaptive Response: increased resistance to radiation.

The recommended dose limit has been revise downward multiple times since 1934. Currently, the US National Council on Radiation Protection and Measurements (NCRP) recommends amaximum annual total body dose of 5 rem and the International Commission on Radiological Protection(ICRP) recommends 2 rem [17]. Eye 15rem, Thyroid gland 30rem, All other organs (including gonads) 50rem,and Pediatrics 10% of adult dose. For reference, a single chest x-ray delivers 0.03rem of radiation. Interestingly, maximum radiation exposure for the gonads does not differ from that for the legs, even with study results suggesting that too much radiation to the gonads may lead to infertility and birth defects, including anencephaly, spina bifida, congenital cataracts, small head circumference, and low birth weight [14]. Most of the radiation orthopedic surgeons are exposed to is not primary radiation from x-ray beam, but scattered radiation. Exposure rates are 1200 to 4000 mrem/min for primary radiation from a standard C-arm and 5 mrem/min for scatter radiation 0.61 m (2ft) from the beam(14),doubling the distance from the source reduces the intensity by a factor offour [14] .

1.5 radiation protection

Standard Measures For Radiation Protection:

There are four primary protective measures which can limit primary and scatter radiation exposure as low as reasonably achievable (ALARA)(30):

1.Maintaining a safe distance from the primary beam and minimizing exposure time can greatly reduce radiation dose [30].

2.Protective garments can effectively reduce exposure to the surgeon and OR staff regardless of distance [30]. These are: (lead apron, thyroid collar shield, by sided eye leaded glasses, leaded gloves, face mask, ceiling suspended screen shield, and mobile floor shield)

3. Contamination control [30].

4. Utilization of computer assisted surgery (CAS) technologies.

CAS does not create additional sources of radiation. Rather, stored radiographic images are utilized during navigation, eliminating the need for additional radiographs and unnecessary exposure [32]. Grutzner and Suhm [33] assessed the effectiveness of CAS generated virtual fluoroscopy during distal locking of peritrochanteric and diaphyseal fractures, as compared to mechanical guidance. As expected, results of the study demonstrated significantly reduced fluoroscopy times in the CAS group.

Proper Radiological Positioning:

Maximize distance between x-ray tube and the patient. Minimize distance between the patient and Image Intensifier. Stand on side of the Image Intensifier . Follow Inverse square law(doubling distance between patient and surgeon will divide radiation dose by factor of four). Tasbas and his colleagues reported that the assistant surgeon is more at risk than the senior surgeon [28]. In the study, they found that the orthopaedic surgeon was always standing at a safe distance (>90cm), but the assistant surgeon always stood nearby (10 cm) to the x-ray source for positioning of the patient. The reading on the badges of the assistant surgeon was more than the orthopaedic surgeon. Alonso and his colleagues studied the effects of scattered radiation during hip fracture fixation and considered that beyond two meters from the radiation source, the scattered dose received was consistently low while within the operating distance, the scattered dose received by staff was high for both lateral and antero –posterior projections [34]. Herscovici advised surgeons to increase their distance from the x-ray beam to reduce the risk from radiation [4]. The NCRP recommends that the surgeon should stand at least two meters (6.6 ft) away from the patient so that the beam intensity is 0.025% of the beam intensity for the patient [30] .

1.6 Reducing Radiation dose

Decreasing dose is achieved by ;decreasing exposure time, reduce field size(collimation), minimize field overlap, avoid unnecessary magnification, use low pulsed fluoroscopy (7 or 3/sec). The risk of increased exposure in junior orthopaedic surgeons is of concern as they may take more exposure and longer duration in performing procedures during their training. Close collimation reduces staff's exposure dose by decreasing Scatter radiation which ismuch lower for smaller field sizes. and it improves image contrast as well. Avoid fluoroing at the edge of the patient,primary radiation hitting the table and not going through the patient results in more and higher energy scatter radiation, and results in higher doses to theoperator's and others. Herscovici advised the orthopaedic surgeons to limit the radiation exposure [18]. Oddy concluded that the principle of minimizing radiation exposure must be maintained by all trainees at all times [23]. Bahari also recommended that routine monitoring of radiation exposure is essential in preventing radiation related diseases [35].Sanders argued that extremity dosimetry for surgeons regularly using x-ray should be considered [24],while Herscovici advised that radiographic units should undergo periodic calibration [18].

Dosimeter :

Is used to measure radiation dose to which surgeon was exposed. There is three types of dosimeters :

1.Out side dosimeter: attached to thyroid collar.

2.Inside dosimeter: worn beneath the lead apron at waist .

3.Finger ring dosimeter.

<u>Instructions for using dosimeter:</u>

1.Wear only your own badge and wear it whenever working with fluoroscopy.

2.Leave it in a cool, dry place away from radiation when not in use.

3.Do not take your badge home.

4. Do not launder the badge or get it wet.

5. Do not expose to heat, such as in a car in summer.

6. Do not expose the badge to other sources of radiation.

7. Do not wear the badge for personal x-ray or nuclear medicine exams.

8. Turn in your badge for processing in a timely manner.

The dosimeter should be followed in a period of one to three months maximally.

Leaded gowns:

There are two options for leaded gowns: 0.25-mm gowns attenuate 90% of radiation and 0.5-mm gowns(which is the optimum) attenuate 99% of radiation, but weigh twice as much [30]. All workers in image intensifier guided surgeries must have a lead apron. Keep the lead between you and the x-ray tube(skirt type lead apron). That is, do not turn your unshielded back to the x-ray tube. Use of wrap around style aprons can help. The old rigid types can be so inflexible as to cause gaps ,when they do not mold to the body. Insist on a well fitting apron. Weight of the aprons varies, A 0.5mm apron can weigh from5to15pounds, depending on the actual composite material. Those have a back problems or for long procedures, may select the lightest 0.5 mm equivalent lead apron. Hang lead aprons on hanging hooks. Do not bend or fold lead aprons or shields. Folding can cause cracks and tears in the protective material. Periodically inspect shields for evidence of damage. Remove damaged ones from use.

Eye Leaded glasses:

Leaded glasses (0.5mm)with sides provide 30% to 70% attenuation and the ordinary glasses alone provide 20%. Eye protection is recommended, as radiation-induced ocular morbidities include transient erythema, ocular opacity, cataract, vision loss, and even ocular tumors [36]. Eye leaded glasses with side shields can provide additional protection to the lens of the eyes. The operator often has to look sideways from the C-arm x-ray tube to see the image on the monitor. This leaves the lens unprotected if glasses do not have side shields.

Thyroid shield:

Thyroid gland shields 0.5-mm thick should also be worn; they attenuate approximately 90% of radiation [30]. Excessive radiation exposure to the thyroid has been shown to lead to thyroidal disorders, including adenomas, thyroiditis, hypothyroidism, and malignant neoplasms [37] . Muller and colleagues discussed the effectiveness of lead thyroid shield in reducing x- ray exposure in trauma surgery interventions of the lower leg. They concluded that the average registered ionizing dose without thyroid shield was 70 times higher as compared to the measurement with thyroid protection [38]. Alonso concluded that the thyroid shield should be made available to operating staff within a two metre zone [34]. Herscovici also advised surgeons to wear protective devices [18].

Radio-Protective Gloves:

However, gloves are not likely to protect hands ifplaced fully into the fluoroscopy beam. When placed fully in the x-ray field, gloves add to the attenuation of the beam, reducing image brightness and producing a large amount of scattered radiation irradiating the hand. Therefore, medical personnel should not rely upon gloves as their principal means of protection during fluoroscopy. If the image of an operator’s finger or hand appears on the monitor, they are being directly exposed. Hands should always be pulled back from the imaged area unless physical control is essential for patient care. Double gloving with conventional latex surgical gloves provides only 1 percent attenuation [39]. Specialized radiation protection gloves can reduce scattered radiation to the hands by as much as58 %. Today’s radiation protection gloves are less bulky and can be used effectively under surgical gloves for interventional procedures. These gloves shield hands from the harmful exposure to scattered radiation and are powder free to reduce any risk of powder related complications. Some manufacturers offer lead free bismuth oxide attenuating specialty gloves. Per unit weight, bismuth oxide provides approximately the same radiation protection as lead, but it has the clear advantage of much lower toxicity. Chronic irradiation of the hands is a principal radiation safety concern for any physician involved in the broad spectrum of high dose fluoroscopically guided interventional procedures(10),and radiation exposure to hands is often the most significant factor in terms of overall radiation risk for physicians who perform the growing number of interventional procedures [40]. Wagner and Mulhern [45] ,found that radio protective gloves provide exposure reduction up to 50% . Other exposure reduction techniques include using the low-dose option on C-arms when maximum resolution is not needed and using a laser guide to center the beam to avoid unnecessary off-center images . Noordeen and colleagues [21] also found that when the surgeon (versus the technician) controls the C-arm foot pedal, there is a significant reduction in radiation exposure.

1.7 General objectives

To assess the Knowledge, Attitude and Practice of the Sudanese orthopaedic surgery registrars in the qualifying training program in protecting themselves against intra- operative radiation exposure.

1.8 Specific objectives

1.To assess the orthopaedic surgery registrars basic knowledge about safety precautions .

2.To assess the registrars attitude and practices at operating rooms towards exposure to radiation.

3. To determine the most important factors related to their level of knowledge , attitude , and practice .

2. Methodology

This is across-sectional KAP(Knowledge Attitude and Practice) study, Orthopaedic surgery registrars training at residency programs in orthopedics surgery enrolled in SMSB(Sudan Medical Specialization Board) training programs in Sudan at the study period . Total coverage by selecting all the rotating orthopaedic surgery registrars(sixty-seven registrars) enrolled in the training program provided by electronic registration office . A questionnaire, consisting of 55 questions , was developed . Survey design and refinement involved literature review . Its validity was documented by a pilot study using a random sample (n = 7) drawn from newly graduated orthopedic surgeons during a 1-month period , for face validity, content validity , and feasibility . Feedback was integrated into the final survey . Standardized questionnaire that was a written document completed by the registrar being surveyed by a face-to-face (58 registrars),or a telephone interview (3 registrars). Data was analyzed by computer using statistical package for social science (SPSS- 21) software and the results were expressed in tables and figures. The test of significant was calculated using P value of 0.05.

3. Results

A total of sixty-seven orthopaedic surgery registrars were invited to participate in the survey which ran from1st of January to1st of march 2014 . At the end of The survey period, Sixty- one (n=61) candidates responded by completing the survey, which represents a return of 91.04%. Seventeen candidates(27.9%) were between twenty-five and thirty years and forty four candidates(72.1%) were more than thirty years . Age did not affect registrars knowledge , attitude , and practice , with P value > 0.05 . Two registrars(3.3%) were females and the rest sixty-one registrars (96.7%) were males. There is no difference between male and female concerning knowledge , attitude , and practice, P value > 0.05 The training levels of all the respondents (n=61)was represented as follows: seven were in the first year, fourteen were in the second year, twenty-five were in the third year , and fifteen registrars were in the fourth year (figure 1). Training year level did not affect level of knowledge , attitude , and practice towards intra-operative radiation protection . P value > 0.05 (table 1-3) . Only four of the candidates (6.6%) attended a workshop about radiation protection , (80.3%) did not read a book or even an article about radiation protection (figure 2,3) , and this was affect their knowledge , attitude , and practice level ; with P value < 0.05 . Only one registrar (1.6%) don't wear lead apron , and he said it is not available (figure 4). Thirteen registrars (21.7%) wear skirt type lead apron . Forty-seven of the registrars (78.3%) wear cracked lead apron several times (figure 5) . Thirty-eight of them (80.9%) said this is the available , while nine registrars (19.1%) did not verify it. Fifty-three of the registrars (86.9%) did not verify thickness of lead apron (figure 6) . thirty-six of them did not know the ideal thickness, and seventeen registrars (32%) said this is due to work load. Fifty-three of the registrars (86.9%) did not wear lead apron as well as other radiation protection garments when needing only one x-ray image . Thirty-three of them (62.3%) think it is of negligible effect , and twenty registrars (37.7%) said because of work load (figure 7). Thirty-two registrars (out of sixty) 53.3% did not hang a lead apron (figure 8) . Fourteen of them (43.7%) said no available hanging hooks, and eighteen registrars (56.3%) they did not care . Only two of the registrars (3.3%) protect their necks by thyroid shield collar from fifty-seven registrars (93.4%) who said it is necessary. Two registrars believe it is not necessary(table 4) . Only one of the candidates (1.6%) wore eye leaded glasses .Except four registrars (6.6%) all said it is a necessary precaution (table 4) . Ten of registrars (16.4%) believe a ceiling suspended shielding screen is not a necessary safety precaution (table 4) . While the rest said it is necessary but not available . All candidates did not use a radio-protective (leaded or lead free) gloves because it is not available , eight of them (13.1%) believe it is not necessary (table 4) . Fifty-two registrars (85.2%) consider reducing fluoroscopy time as a necessary radiation protection measure , and only twelve of them (19.7%) act to reduce it during image intensifier guided procedures . Nine registrars (14.8%) believe that reducing fluoroscopy time is not a necessary precaution towards radiation protection (table 4) . Fifty-five registrars (90.2%) consider an increasing distance from a patient during fluoroscopy as a necessary radiation protection precaution , but only eleven of them (18%) follow it in their usual practice (figure 9) . Six registrars (9.8%) believe it is not necessary (table 4) . Forty-five of the registrars (73.8%) did not keep their hands out the primary beam (figure 10) Twenty-three of them (51.1%) said it is not avoidable , while twenty-two registrars (48.9%) did not care . All registrars did not protect their legs by mobile floor shield, they said it is not available. Five registrars (8.2%) believe it is not a necessary radiation protection precaution (table 4) . All registrars did not wear personal dosimeter because it is not available . And forty-one of the registrars (67.2%) did not know the annual occupational radiation dose limit for eye lenses . Thirty- five registrars (57.4%) did not stand on the correct side (image intensifier side) during fluoroscopy (figure 11) . Twenty-four of them (out of thirty-five) 68.6% did not know where to stand, eleven registrars did not care . Forty-five registrars (73.8%) prefer image magnification. Forty of them (88.9%) said because it gives clear anatomy, while six registrars (11.1%) believe it decreases need for radiation . Twenty-three of the registrars (37.7%) believe that scatter radiation is not the main source of radiation affecting the theatre staff (figure 12) . Thirty-four of the registrars (55.7%) need un planned x-ray when already they are operating without wearing a protective measures . This occurs several times for thirty-one registrars . Only one registrar wash again after wearing lead apron , while the rest have no action . We categorize the registrars according to their level of knowledge , attitude , and practice by giving excellent to those achieve ≥ 7 out of ten , accepted for five to seven out of ten , and poor level for less than five . No excellent level . only fifteen (24.6%) , twelve (19.7%), and seven registrars (11.5%) have accepted level of knowledge, attitude, and practice towards intra-operative radiation protection respectively (figure 13-15). There is a significant relationship between radiation protection workshop attendance and level of knowledge, attitude and practice with P value 0.0003,0.004 and 0.0000 (table 8-10) respectively. Also those who read a literature about radiation protection have a better knowledge with P value 0.0000 (table 5) , attitude with P value 0.0000 (table 6) . Their practice to lesser extent better than those not read an article regarding radiation protection at all with P value 0.1010 (table 7) .

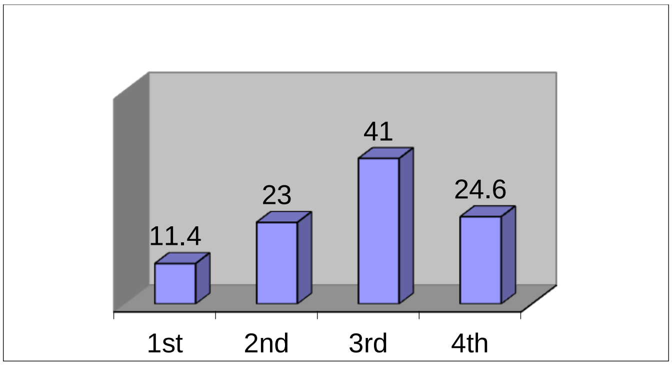

Figure 1: Distribution of the registrars according to the year of rotation .

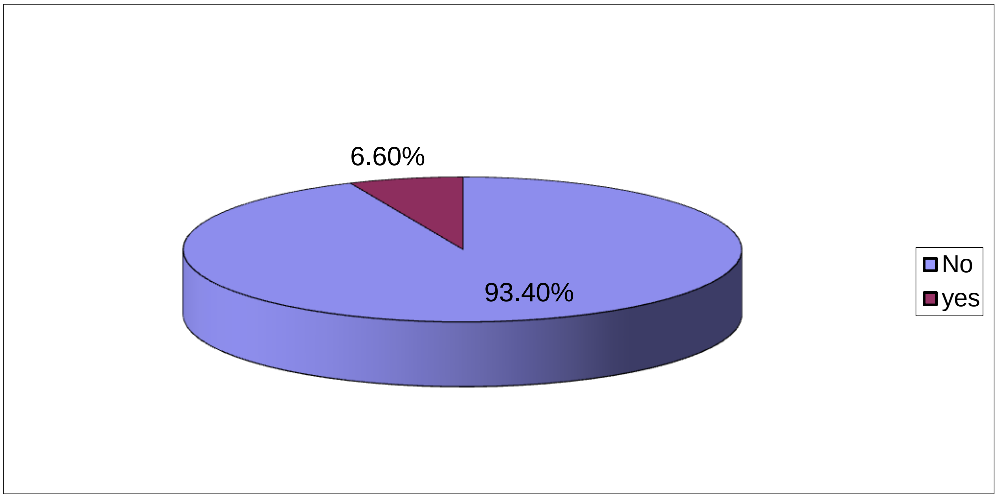

Figure 2: Distribution of the registrars according to radiation protection workshop participation.

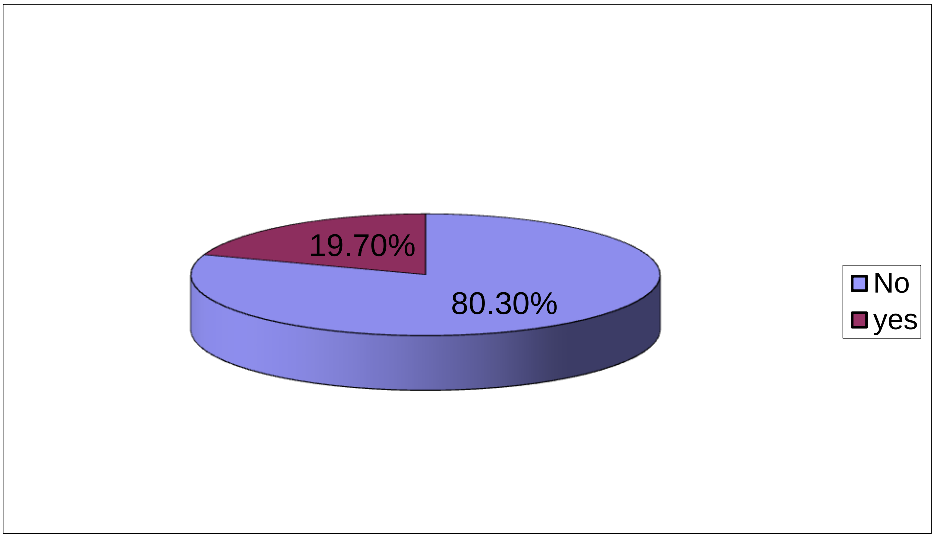

Figure 3: Distribution of the registrars according to reading a literature about radiation protection.

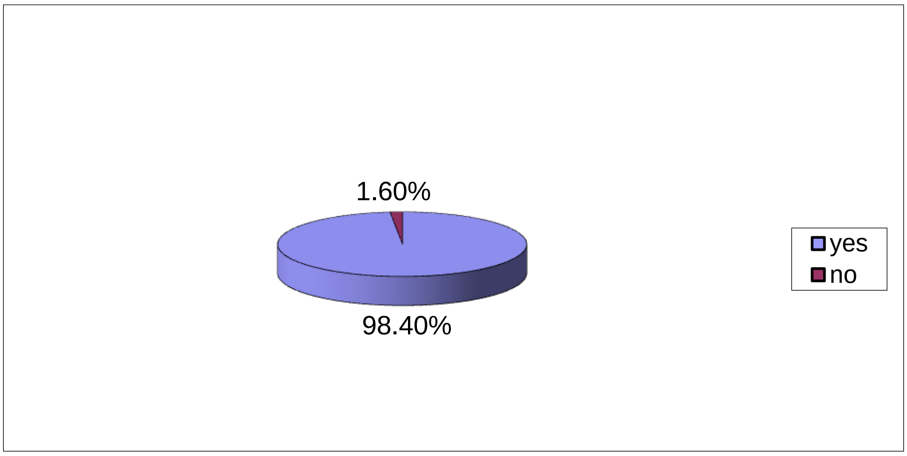

Figure 4: Distribution of the registrars according to wearing lead apron.

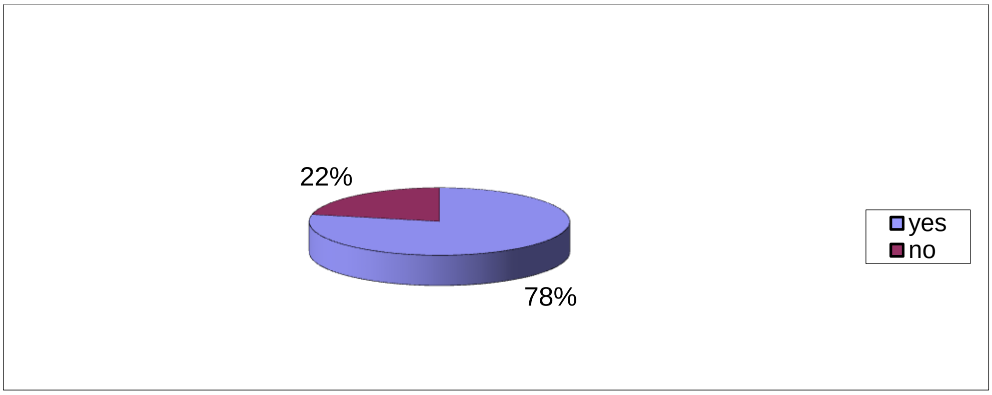

Figure 5: Distribution of the registrars according to wearing cracked lead apron.

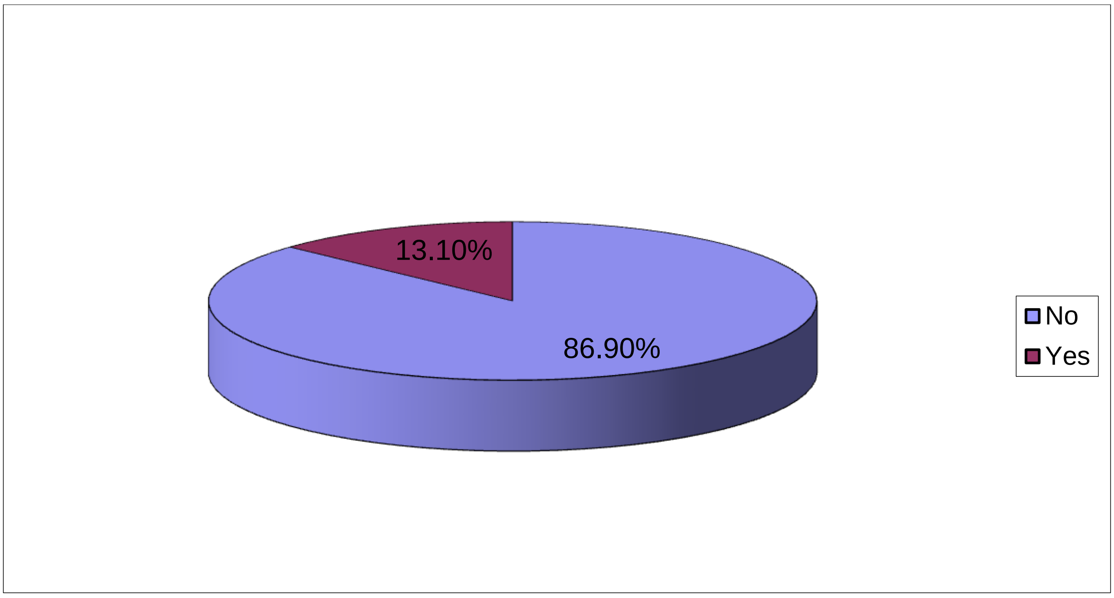

Figure 6: Distribution of the registrars according to verification of lead apron thickness.

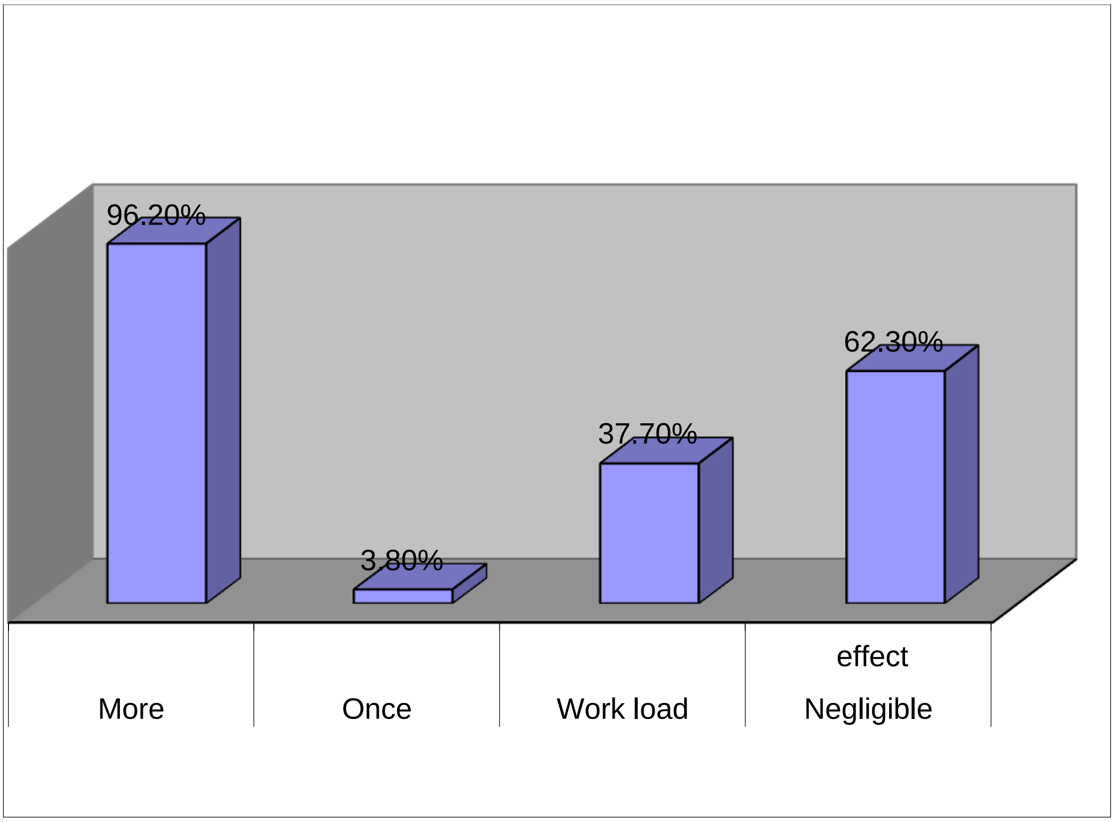

Figure 7: Distribution of the registrars according to why and how many times not wearing lead apron and other protective garments when need only one image.

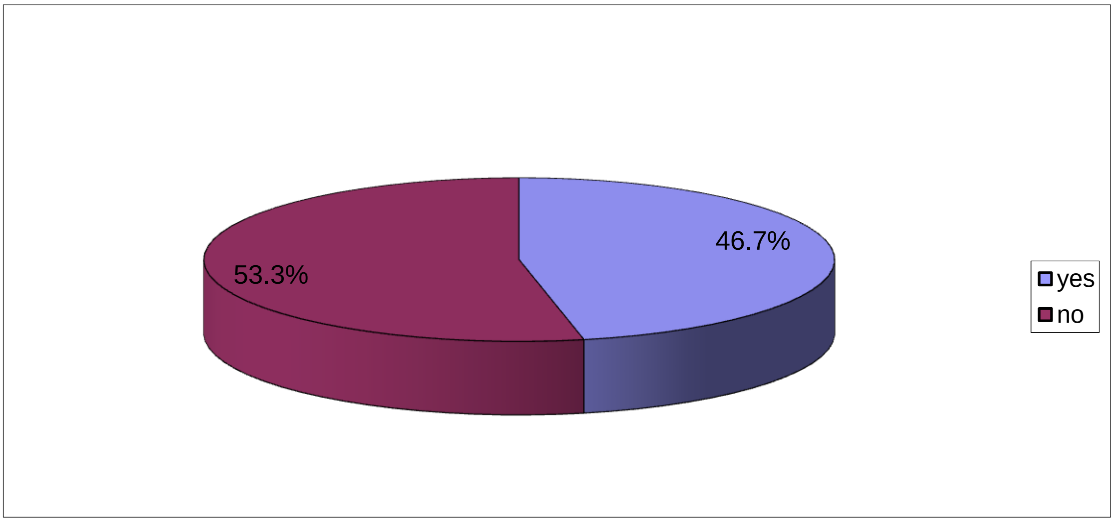

Figure 8: Distribution of the registrars according to hanging lead apron on hanging hooks.

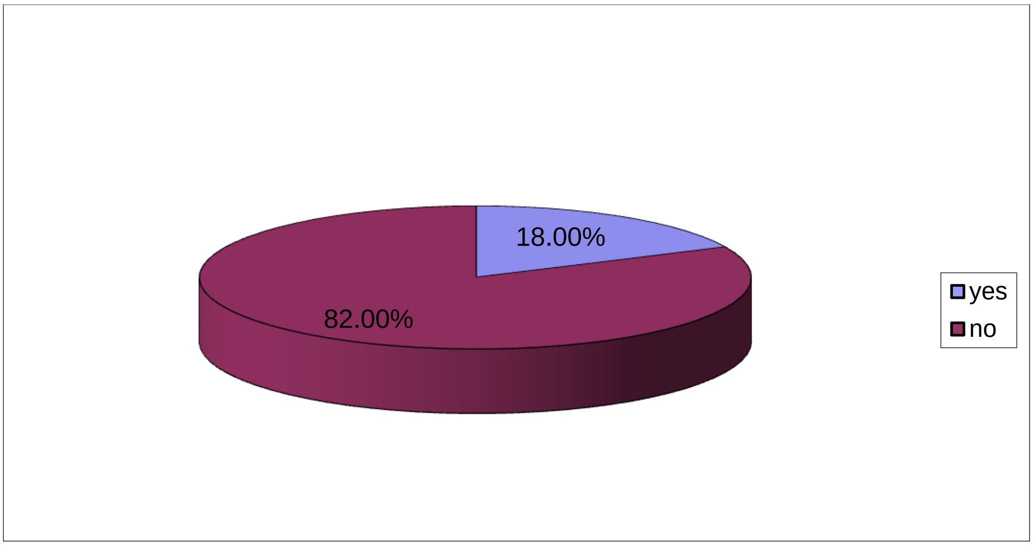

Figure 9: Distribution of the registrars according to stepping back when fluoroscopy on

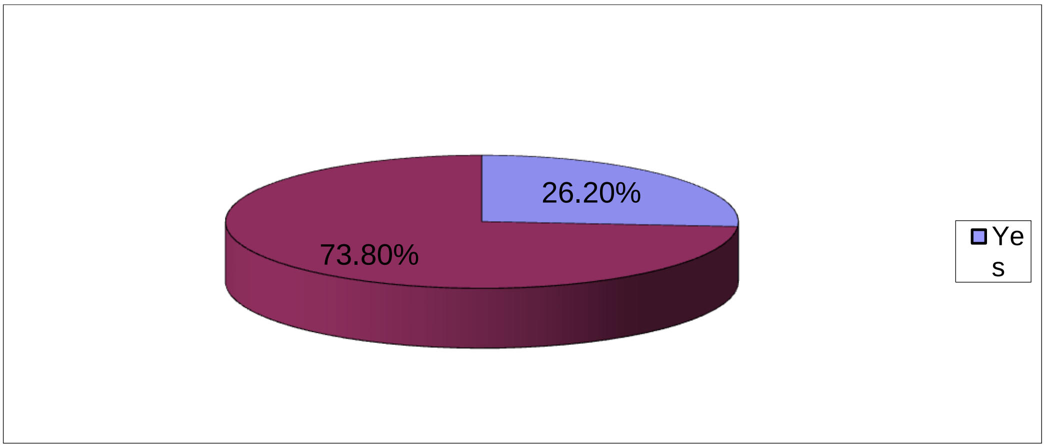

Figure 10: Distribution of the registrars according to keeping hands out the primary beam.

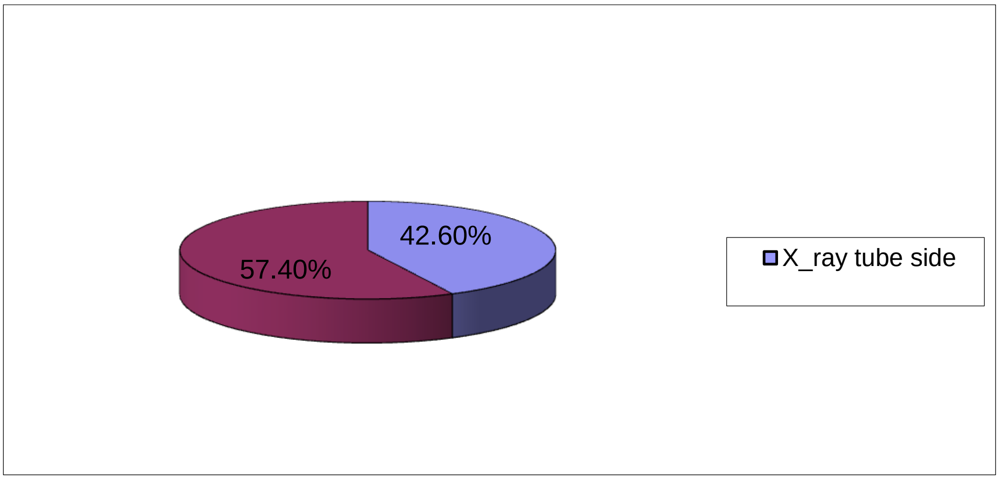

Figure 11: Distribution of the registrars according standing position during fluoroscoping.

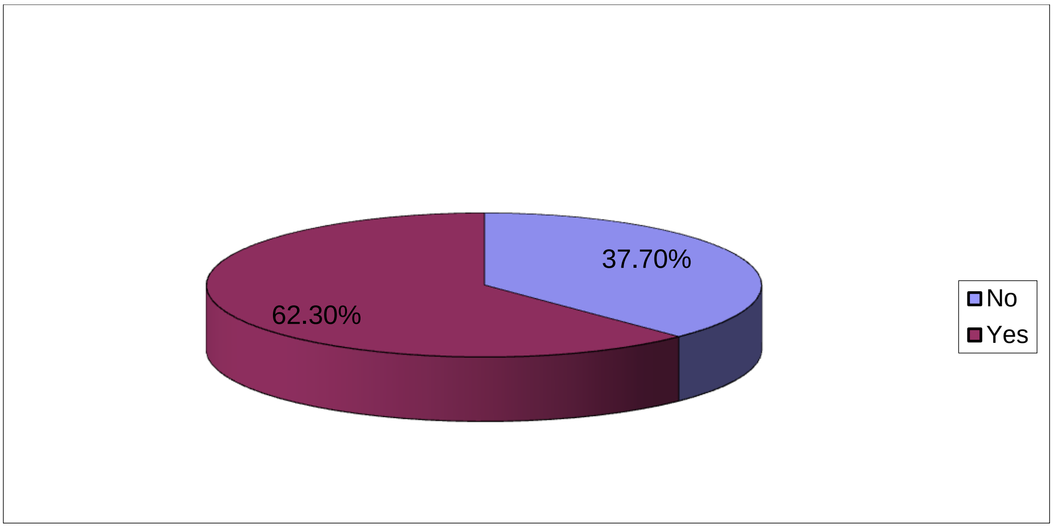

Figure 12: Distribution of the registrars according to knowledge about scatter radiation as the main source of radiation affecting the staff.

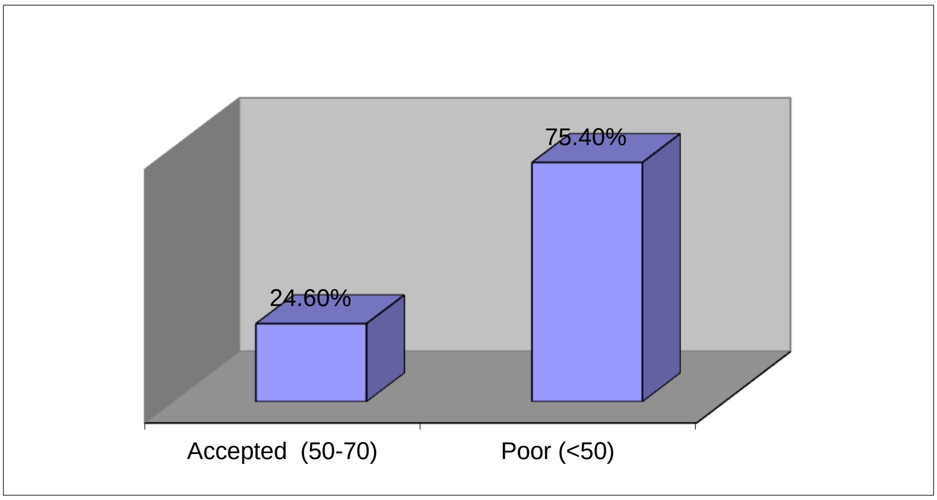

Figure 13: Distribution of the registrars according to their knowledge score.

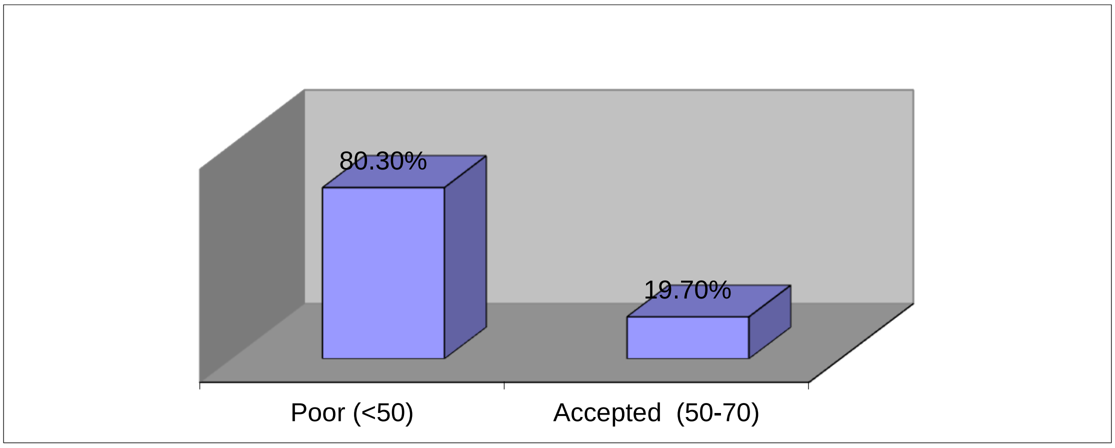

Figure 14: Distribution of the registrars according to their attitude score.

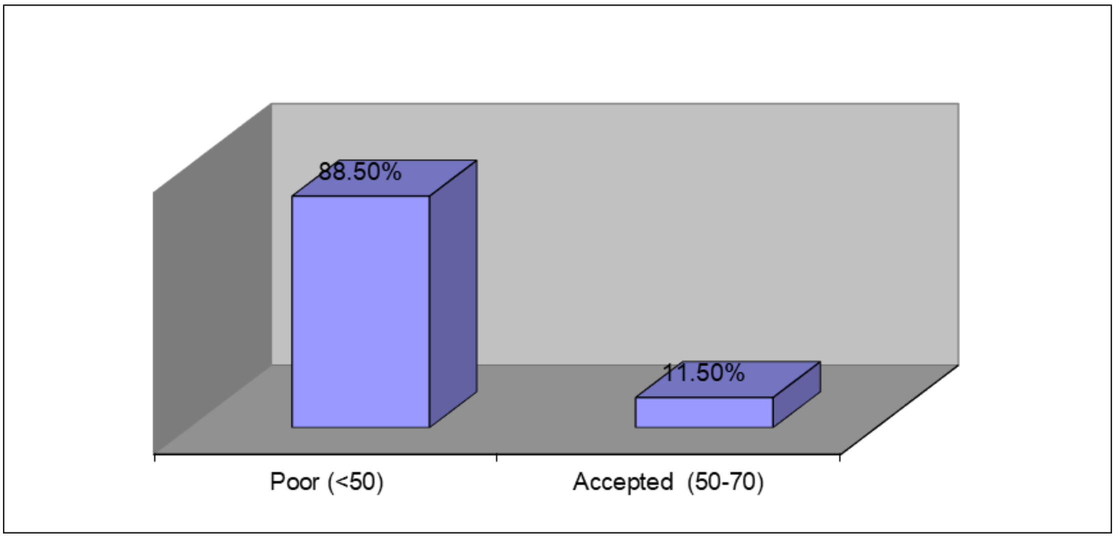

Figure 15: Distribution of the registrars according to their practice score .

Table 1: Relation between Knowledge level and rotation year:(n=61)

Yr in rotation	Excellent (≥7)	Accepted (5-7)	Poor (<5)
1st (n=7)	0	1(14.3%)	6(85.7%)
2nd (n=14)	0	3(21.4%)	11(78.6%)
3rd (n=25)	0	6(24%)	19(76%)
4th (n=15)	0	5(33.3%)	10(66.7%)

Chi-square P.values=0.777232

Table 2: Relation between Attitude level & rotation year: (n=61)

Yr in rotation	Excellent (≥7)	Accepted (5-7)	Poor (<5)
1st (n=7)	0	0	7(100%)
2nd (n=14)	0	2(14.3%)	12(85.7%)
3rd (n=25)	0	6(24%)	19(76%)
4th (n=15)	0	4(26.7%)	11(73.3%)

Chi-square P.value=0.434807

Table 3: Relation between Practice level & rotation year: (n=61)

Yr in rotation	Excellent (≥7)	Accepted (5-7)	Poor (<5)
1st (n=7)	0	0	7(100%)
2nd (n=14)	0	1(7.1%)	13(92.9%)
3rd (n=25)	0	4(16%)	21(84%)
4th (n=15)	0	2(13.3%)	13(86.7%)

Chi-square P.value=0.632302

Table 4: Distribution of registrars according to their knowledge and practice of standard precautions:(n=61)

precautions	Necessary	Unnecessary	Usual practice
Lead apron	61(100%)	0	60(98.4%)
Thyroid shield	59(96.7%)	2(3.3%)	2(3.3%)
Eye leaded glasses	57(93.4%)	4(6.6%)	1 (1.6%)
Ceiling suspended shielding screen	51(83.6%)	10(16.4%)	0
Flexible(leaded or lead free radio- protective)gloves	53(86.9%)	8(13.1%)	0
Reduced fluoroscopy time	52(85.2%)	9(14.8%)	12(19.7%)
Increasing distance from pt while x-ray on	55(90.2%)	6(9.8%)	11(18%)
Mobile floor shield	56 (91.8%)	5 (8.2%)	0

Table 5: Relation between Knowledge level & reading radiation protection article : (n1=6)

	Excellent (≥7)	Accepted (5-7)	Poor (<5)
Reading RP article(n=12)	0	12(100%)	0
Not reading RP article (n=49)	0	3(6%)	46(94%)

Chi-square P.value=0.0000

Table 6: Relation between Attitude level & reading radiation protection article : (n=61)

	Excellent (≥7)	Accepted (5-7)	Poor (<5)
Reading RP article(n=12)	0	8(66.7%)	4(33.3%)
Not reading RP article (n=49)	0	4(8%)	45(92%)

Chi-square P.value=0.0000

Table 7: Relation between Practice level & reading radiation protection article : (n=61)

	Excellent (≥7)	Accepted (5-7)	Poor (<5)
Reading RP article(n=12)	0	3(25%)	9(75%)
Not reading RP article (n=49)	0	4(8%)	45(92%)

Chi-square P.value=0.1010

Table 8: Relation between Knowledge level & attending radiation protection work shop :(n=61)

	Excellent (≥7)	Accepted (5-7)	Poor (<5)
Attending RP workshop (n=4)	0	4(100%)	0
Not attending RP workshop(n=57)	0	11(19.3%)	46(80.7%)

Chi-square P.value=0.0003

Table 9: Relation between Attitude level & attending radiation protection work shop : (n=61)

	Excellent (≥7)	Accepted (5-7)	Poor (<5)
Attending RP workshop (n=4)	0	3(75%)	1(25%)
Not attending RP workshop(n=57)	0	9(15.8%)	48(84.2%)

Chi-square P.value=0.004

Table 10: Relation between Practice level & attending radiation protection work shop : (n=61)

	Excellent (≥7)	Accepted (5-7)	Poor (<5)
Attending RP workshop(n=4)	0	3(75%)	1(25%)
Not attending RP workshop(n=57)	0	4(7%)	53(93%)

Chi-square P.value=0.0000

4. Discussion

Orthopaedic surgeons are at higher risk of radiation exposure, and in general they know very little about radiation , its effect on human health, and how to protect themselves against it [16]. The assistant surgeon isat more risk than the senior surgeon [29]. In this study females (less than 4%) and males were not evenly represented , and the opinions of both males and females were combined and represented without making reference to a specific gender. The largest group of registrars was on the third and fourth year of rotation, which may explain the age difference (72.1% were more than 30 years). In this study 98.4% of the registrars said they stick to lead apron (table 4) . This result is similar to study among radiographers in various hospitals in Hamadan city (Iran) which published on 2011 at Journal of Paramedical Sciences (JPS) .In this study 98.6 % of employees aware about personnel protection devices specified to lead apron and thyroid shield [41]. Other study by Kerman and his colleagues (Iran) [42] showed that only 78.9% of participants wear lead apron . Although cracked lead apron increases the risk of radiation exposure , more than 78% of the registrars wear a cracked lead apron (figure 5) and claimed that this what available . In this study thirty-four registrars found themselves facing radiation un wearing the protective garments when they needed x-ray check which is un planned preoperatively and this occurs several times (figure 7) , but unfortunately only one registrars responded well by ceasing what he is doing and wearing lead apron then returned back to his work , the rest have no action . Most of the orthopaedic surgery trainees (96.7%) in this study did not wear the thyroid shield, and the majority of them (96.6%) claimed that it is not available . These finding were higher than what showed by a similar study done in 2010 in the UK [43] , where (76%) of surgical trainees did not wear the thyroid shield , and most of the trainees (70%) did not aware to thyroid shield in the same study .In our study only (3.3%) of the registrars were un aware of thyroid shield . In this study (37.7%) of the candidates did not knew scatter radiation as the main radiation affecting the theatre staff (figure 12) .This result is lower than that obtained from a study done in UK [43] , where 70% (35 out of 50) of participants did not knew . Despite by sides eye leaded glasses are greatly necessary for eyes protection , but unfortunately only (1.6%) of the registrars wear it . most of them said that it was not available . No similar study in the literature was available to compare .In our study 67.2 % of trainees did not know the annual occupational dose to eye lens , this is higher than what obtained from study done in shiraz (Iran) in 2011 where 18.3% did not know the annual occupational dose limit [44]. Although 73.8% of the registrars in this study did not keep their hands out the primary beam (figure 13) , and 51.1% of those said it is not avoidable , there was no body in our study wear a radio-protective gloves, some of trainees (13.1%) were not aware about it even (table 4) .There is no similar study to compare . Wagner and Mulhern [28] found that radio-protective gloves provide exposure reduction up to 50% . All trainees did not protect themselves by mobile floor shield . The majority (91.8%) claimed it is not available , while (8.2%) of registrars were not aware about it (table 4) . The results of this study showed that the orthopaedic surgery registrars are lacking in the essential knowledge of protection against ionizing radiation in orthopaedic trauma surgery . Unfortunately, most registrars in this study were unaware and did not adhere to radiation safety principles ALARA [31], which aim to maintain exposure to radiation as low as reasonably achievable when performing fluoroscopically guided procedures (e.g only 18% and 19.7% increased the distance from a patient during fluoroscopy, and reduced a fluoroscopy time respectively). When analyzing their source of knowledge we found that most of them (80.3%) had never read a literature about radiation protection (figure 3), which will be reflected in their response . These findings were a little lower than what obtained from study about awareness and attitudes amongst basic surgical trainees from England and Wales regarding radiation in orthopaedic trauma surgery [43], where most of the trainees (84%) did not read radiation safety literature . Twelve trainees read an article concerning radiation protection and all have accepted knowledge with P value 0.0000(table5), (66.7%) of them have accepted attitude with P value 0.0000 (table 6), and (25%) have accepted practice with P value 0.1010 (table7). Most of registrars (93.4%) in our study did not attend work shop about radiation protection , and this explain why poor knowledge , attitude , and practice . This is significantly high when compared to study done in shiraz (Iran) (44) where less than half of the participants(43.7%)have participated in a radiation protection course . All registrars who attended a radiation protection workshop have accepted knowledge with P value 0.0003 (table 8) , 75% of them have accepted attitude and practice with P value 0.004 and 0.0000 (table9 ,10) respectively . This attendance can be improved by a regular workshops and tutorials throughout the training program .After analyzing 53 questions, the overall result is poor, we found that 24.6% have accepted knowledge, 19.7% have accepted attitude and 11.5 % have accepted practice (figure13-15) . These results are similar to an international study published on January 2010 at Biomedical Imaging and Intervention Journal which showed that surgical trainees have poor knowledge concerning ionized radiation protection [43], also similar to study result done in Tunisia among operating theatre staff (OTS) where the results indicate insufficiency in OTS knowledge's and inradio-protection tools availability [45].

5. Conclusion

The knowledge, attitude and practice of most orthopaedic surgery registrars towards intra-operative radiation protection is poor. Most of the registrars did not come across even a single article or workshop concerning the radiation protection. Factors affecting the overall knowledge, attitude and practice were found to be workshops attendance and reading articles concerning radiation protection .

6. Recommendations

1. Knowledge concerning radiation protection should be an active part of training curriculum and final MD exam .
2. Supervised use of image intensifier for registrars is mandatory .
3. Provision of radiation protection garments and tools is essential
4. Provision of dosimeters is mandatory .

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