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Research Article

Radiation Safety For Operating Room Technicians

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Abstract:

Abstract Radiation safety is an important consideration for operating room technicians, in procedures that involve the use of fluoroscopy or other imaging technologies that emit ionizing radiation. Radiation safety is essential to safeguard human health, minimize radiation exposure, optimize medical radiation use, protect the environment, and comply with regulatory standards. By implementing appropriate safety measures, radiation can be used safely and responsibly in various fields, balancing the benefits of radiation applications with the need for protection against potential harm. It is important for operating room technicians to adhere to radiation safety guidelines and best practices to protect themselves, their colleagues, and patients from unnecessary radiation exposure. Collaboration with radiation safety officers, radiation safety committees, and other relevant experts can help ensure a culture of safety and ongoing improvement in radiation safety practices. The aim of this article is to inform the operating room technicians about radiation, to keep their occupational exposure to a minimum is to help.

1. Introduction

Surgical interventions were considered risky and the last option in treatment until the 19th century, but over the years, the number of surgeries has increased thanks to the development of technology, change in aesthetic perception, increase in population, increase in the number of elderly population, traumas due to the use of industrial tools and equipment, current diagnosis and treatment methods, evidence-based practices, decrease in complication rates, effective anaesthesia methods and qualified care during the operation process [1,2,3].

Especially in the last 30 years, with the emergence of minimally invasive surgical techniques, robotic surgery and the increase in the number of hybrid operating theatres; patient safety, recovery rate, shortening of hospital stay, pain control, decrease in complication rate, rapid return to daily life, achieving better cosmetic results as a result of surgery and patient psychology [2]. There is an increase in the number of surgical interventions performed both in the world and in our country. Below, the statistics of the surgeries performed are given with current data.

According to the Republic of Turkey Ministry of Health Health Statistics Yearbook 2020 (published in 2022); while the total number of surgeries performed in 2002 was 1598362, this number increased to 5223815 in 2019, and the number of surgeries decreased due to COVID19 in 2020 and became 3722218. In 2020, it was reported that 44.5 out of every 1000 people in Turkey underwent surgery [4].

According to the European Community Statistical Office (Eurostat, European Community Statistical Office), 2020 data, the most common surgical interventions in Europe are cataract surgery, caesarean section, coronary angioplasty, hip replacement, cholecystectomy, appendectomy, inguinal hernia and hysterectomy. According to the same data, 1,461 cataract operations were performed per 100000 people in Latvia, while 473,1 cataract operations were performed in Turkey. Turkey has the highest caesarean section rate (764,1/100000). Coronary angioplasty was most common in Croatia (462/100000) and Germany (384/100 000), while hip replacement was most common in Germany (294/100000). Comparing 2010 and 2020, an increase was observed in laparoscopic applications

and especially in laparoscopic hysterectomy, while a decrease was observed in tonsillectomy [5].

In the cohort study by Mattingly et al (2021), it was found that with the publication of the recommendation to cancel elective surgical interventions due to COVID-19 in the USA; the number of surgical interventions performed decreased by 48% within seven weeks, the most affected interventions were cataract interventions with a decrease of 89.5%, and the least affected were organ transplantation interventions with a decrease of 20.7%. In the same study, it was observed that the number of surgical interventions rapidly returned to the initial level after the initial closure [6]. Fingar, Stocks, Weiss, and Steiner reported that the three most common surgical procedures requiring maternal and non-neonatal hospitalisation in the USA in 2012 were arthroplasty (700,100), percutaneous coronary angioplasty (534,600) and lumbar laminectomy (468,200) [7]. It was observed that musculoskeletal operations were the most common. Comparing 2003 with 2012, they concluded that there was an increase of more than 150% in the number of gastrectomy procedures [7]. Working in a healthy environment is as important as the right to live. In this context, the concept of occupational health and safety comes to the fore. Occupational health and safety includes ensuring that employees are both physically and psychosocially healthy and making the tools and working conditions used in the workplace more suitable. At the same time, it aims to protect human health against existing hazards and to find solutions to these problems by identifying existing health problems [8,9]. The International Labour Organization (ILO, International Labour Organization) and the World Health Organization (WHO, World Health Organization) publish current declarations on occupational health objectives [10]. According to WHO, occupational health is to improve the physical, mental and social well-being of employees in all occupational groups at a high level and to maintain this development. Ensuring occupational health and safety is a fundamental right of the employee [11]. The main objective of ILO is to establish basic labour standards for the government, employers and workers and to ensure that every employee works within the scope of social protection, taking into account fundamental rights and principles [12]. According to Bilir, "When hazards in the working environment cannot be prevented, they lead to risks, and when risks cannot be prevented, they lead to workrelated health problems, occupational accidents and related disability, incapacity for work and absenteeism from work" [13]. Hospitals harbour significant risks in terms of occupational health and safety. According to the Communiqué on Workplace Hazard Classes of the Occupational Health and Safety Law No. 6331 published in 2012, hospitals are classified as "Very Hazardous Workplace [14]. While the injury rate in the industrial field is 0.3%, this rate was found to be 13.2% in healthcare workers [15]. In the world, approximately 59 million healthcare workers working in healthcare organisations are exposed to health and safety risks (Solmaz and Solmaz 2017). Operating theatre workers are faced with various safety and health hazards. The risks in the operating theatre can cause disease development, injuries, occupational accidents and labour force losses [16].

Potential risk factors in operating theatres can be listed as blood-borne pathogens, chemical and drug exposures, anaesthetic gas exposures, ergonomic hazards, latex allergy, psychosocial risks, sharps injury, infection, radiation, laser, surgical smoke and fire hazards [2,17].

It is desirable to completely eliminate these risks in the operating theatre and zero risk is a desirable situation, but it is possible to reduce risks, although it is not possible to completely prevent risks. Reducing the risks positively affects the health of the employees and also positively affects the society benefiting from the service by increasing the quality of health services. Health professionals have important duties to increase the motivation and work performance of the operating room team, to create a safe and healthy environment, and to minimise these risks [9,18]. In the general information section, information on surgical smoke and radiation will be included among the risks encountered in the operating theatre.

2. Health and Safety of Operating Theatre Staff

With the development of technology and industrialisation, working conditions negatively affect the health and safety of employees. It is the right of every employee to have a healthy and safe working environment and businesses must comply with the laws on this subject [19]. The main objective of occupational safety is to protect employees. In other words, it is to protect the mental and physical health of employees by creating comfortable and safe working conditions by protecting employees from negative effects in the workplace, occupational accidents and occupational diseases [20]. Occupational health and safety is also valid in health institutions which are a business. Although the risks and hazards that health workers are exposed to are different, it is important to regulate and implement occupational health and safety to protect employees from these hazards. The

2012 "Regulation on Ensuring Patient and Employee Safety" aims to protect the health and safety of employees. In the official gazette dated 25 November 2009, with the "Communiqué on the List of Hazard Classes Regarding Occupational Health and Safety", hospitals were included in the "Very Hazardous Work" class and radiology, radium, radioactive substances, i.e. work with radiation emitting devices, hospital, bacteriology and chemistry laboratories, pharmacy work were included in the heavy and dangerous work class [21].

Due to the fact that hospitals serve the society and can affect the health of patients, sufficient importance should be given to ensure that the occupational health and safety of healthcare workers is at the best level [21]. In the United States of America, the National Institute for Occupational Health and Safety (NIOS) reported that there are different hazards [22]. NIOS defines a healthy and safe hospital environment as "the absence of occupational diseases and occupational accidents due to physical, chemical, biological, ergonomic, mechanical hazards and risks that occur in relation to the execution of the work and harm health" [20].

Biological hazards are present in all health care areas. Infections such as HIV (Human Immunodeficiency Virus), Hepatitis B virus (HBV), Hepatitis C virus (HCV), tuberculosis, intestinal infections and infections such as Brucella, Salmonella are found in healthcare personnel and in the working environment after contact with the patient's blood or areas contaminated with blood [21].

Chemical hazards; many chemicals are used in the hospital. It is possible for anaesthesia substances, substances used in sterilisation, disinfectants used in health care, antibiotics or cancer drugs to enter the employee's body for different reasons such as inhalation, contact or needle prick during the preparation, transport and application stages.

Psychosocial hazards; Job dissatisfaction, monotonous work, lack of rest periods and number of personnel, the necessity to work irregularly and in shifts, stress caused by being responsible for the care of the sick and the deceased constitute psychosocial hazards.

Ergonomic hazards; Healthcare workers are overweight, heavy, unconscious patients, lifting, carrying or holding the falling patient, excessive effort, situations such as being asked to do work above physical competence cause musculoskeletal complaints in healthcare workers. Pain in the waist, neck, arm and carpal tunnel syndrome are musculoskeletal disorders that can be seen in healthcare workers [21].

Physical hazards; radiation, noise, carcinogenic agents, poor ventilation, lighting, heat - humidity, photocopiers and computer screens constitute physical hazards for health workers [22]. Radiation is a Latin word and is used as radiation in our language. The energy emitted from atoms, the sun and other stars is called radiation. Radiation is emitted in the form of energy or wave or particle model [23]. Radiation is divided into two as ionised and non-ionised, the most dangerous is ionised radiation and radiation causes occupational diseases. Ionising radiation causes genetic, congenital disorders or reproductive health disorders by damaging the cells that form the most basic of the body [24]. X-rays, which are ionising radiation generated by C-armed scopi devices used in some surgical cases in operating theatres, can easily penetrate deep into the body and have a destructive effect by penetrating the tissues. X-rays are frequently used in medicine to examine internal organs or to investigate whether there is a fracture in a bone [23]. Distance, time and armouring are important in radiation protection. The intensity of the magnetic field is inversely proportional to the square of the distance from the source and the density of the environment in which it spreads. It is necessary to live as far away from these lines as possible and if possible, these lines should be under the ground. Operating theatre workers are exposed to ionising radiation and radiation protection rules, radiation damages will be examined in the second part under the title of radiation safety.

3. Radiation Safety in the Operating Room

Radiation can be emitted from non-ionising devices such as laser type non-ionising devices and portable X-ray devices in the operating theatre environment, as well as from methods such as fluoroscopy and X-Ray, the use of which has increased in recent years [25].

Radiation has stochastic and deterministic effects on body organs. Stochastic effects express the risk of developing cancer with the radiation dose independent of the dose received. Deterministic effects, on the other hand, indicate that there is a threshold dose and this threshold must be exceeded for observable effects to occur. It has been shown in many studies that exposure to low levels of ionizing radiation in diagnostic radiological examinations can cause leukemia, thyroid, lung and breast cancer [26-29].

Radiation exposure during surgery is higher in orthopaedics, urology and neurosurgery [2]. In a study by Mariscalco et al, it was found that the amount of radiation exposure during open surgical interventions was significantly lower than the amount of exposure during minimal surgical intervention applications [30]. In addition to making life easier, radiation-containing devices have a serious negative impact on health. Balancing benefit and harm is one of the important rules of radiation [31]. Radiological interventions that will not contribute to diagnosis and treatment put patient and employee health at risk [32].

Radiation exposure occurs in three different ways: direct, reflection and leakage. Infiltration is caused by fluoroscopy and reflection is caused by the patient or the instruments in the operating theatre [33]. In the literature, there are studies showing that the safe distance for radiation protection varies between 46-200 cm [34].

Biological damage caused by radiation varies depending on the type and energy of radiation, how long the dose is received, how much dose the target can absorb and the properties of the target tissue. Target tissue characteristics, cell division frequency and metabolic activity, the amount and duration of the tissue's ability to absorb the dose are considered among the factors affecting biological damage [35].

Exposure to low-dose X-rays is associated with thyroid diseases, leukaemia, breast and lung cancer. Organisations such as IARC and WHO also confirm that X and gamma rays carry cancer risk [36]. In a study conducted on survivors of the Hiroshima and Nagasaki atomic bomb attack, it was observed that the risk of thyroid cancer was significantly higher in people exposed to ionising radiation at paediatric age [37].

In medical applications, there are certain limits to the radiation level that both the patient and the healthcare worker can receive. It is very important for people who apply radiation for medical purposes to know and apply these limits in order to keep the radiation level that the public will receive at a certain level [38].

It is very important to protect the employees from the harmful effects of ionising radiation, which is a physical hazard that also falls within the scope of occupational health, to inform them and to provide them with the necessary behaviours. X-rays, which are in the electromagnetic radiation class, are also used in the image formation of the C-arm scopy device used in some surgical approaches to patients, and prolonged exposure to small doses can adversely affect the health of employees. Although protecting employees from the harmful effects of radiation is one of the topics of occupational health and safety, it is important to explain the necessary information to understand the ways of protection and damages under the subject of radiation safety, and information about radiation is explained under this heading.

The atom, which is the smallest part of the element that carries its own characteristics, consists of a nucleus consisting of protons and neutrons and negatively charged electrons orbiting the nucleus [39]. The energy levels of the orbit where the electrons are located are different in each orbit. Energy levels increase from outside to inside [40]. The excitation of electrons for any reason allows them to settle at higher or lower levels related to the energy they will gain [41]. The energies carried in the form of fast particles and electromagnetic waves emitted by natural or artificial radioactive nuclei that want to pass to a stable structure are defined as "radiation" [42]. Radiation is electromagnetic waves or particles emitted from a source [43].

While some of the nuclei of atoms in nature are stable, others are unstable. Since the protons and neutrons in a stable nucleus are bound to each other by tight bonds and nuclear forces, the nucleus will remain in equilibrium since the particles cannot escape from the nucleus. If the nucleus is unstable or out of equilibrium, the particles will not be able to stay together with the excess energy it has, and will discharge its excess energy in a short or long time. Unstable nuclei are called "radioactive nuclei" or "radioisotopes". The condition of unstable nuclei emitting radiation to the environment during the decay period in order to become stable is called "radioactivity" [41].

Today, according to International Radiation Protection (ICRP) recommendations, annual dose limits for radiation officers are 20 mSv, and dose limits for patient relatives are 5 mSv [44-45]

4. Biological Effects of Ionising Radiation

Knowing and examining the biological effects of ionising radiation is important in terms of providing the necessary behaviour in radiation protection. As ionising radiation passes through tissues, it stimulates the atoms in the tissue and causes ionisation or disruption of their molecular structures [36]. The biological effects of ionising radiation on the irradiated tissue vary according to the size of the dose, the effects on the irradiated parts of the body, the characteristics of the irradiated area and the type of radiation emitted. The effect of radiation

occurring at large doses is called deterministic effect [46].

The quality of education to be given to people who will use these devices gains importance in terms of preventing early, late and hereditary effects that may occur due to unnecessary and/or high radiation exposure of patients, patient relatives and working personnel during imaging methods using ionizing radiation [47]

Death, skin burns, cataracts, infertility are examples of this effect. The effect that occurs at doses too small to cause cell damage is called stochastic effect and very small doses are sufficient for this effect to occur, it is a dose-independent effect. Cancer and genetic effects can be examples [25]. The factors on which the biological effects of radiation depend vary according to factors such as the type of radiation affecting the organism, the amount of radiation to which the organism is exposed, the duration of exposure to radiation, the way it is affected by radiation [48]. The degree of sensitivity of the organism region to radiation; reproductive cells, eye lens and retina, lymphocyte type of leucocytes, bone marrow, spleen, skin and small intestines are sensitive to radiation (radiosensitive), muscle, nerve and mature bone cells are resistant to radiation (radioresistance) [41].

5. Early Effects

These are the effects that may occur when a certain part of the body or the whole body is exposed to high doses of radiation dose in a short time. The effects that will occur with acute irradiation show their effects according to variables such as the radiation dose received and the duration of exposure. These effects manifest themselves as severe damage, burns or death within a few days or weeks [28,35]. This type of irradiation, also called acute irradiation, is usually unintentional irradiation resulting from an accident. The main cause of accidents is observed to be the loss, theft or otherwise out of control of radiation sources. Unfortunately, despite significant developments in radiation safety practices, such accidents that can harm people can still occur [18,26]. The effects that may occur as a result of acute irradiation can be generally classified as acute radiation syndromes and local radiation damage.

6. Radiation Syndromes

It develops as a result of acute irradiation of the whole or a large part of the body. Within a few hours after exposure, symptoms such as nausea, vomiting, diarrhoea, headache, fever, loss of consciousness and a decrease in blood cell count occur. After two to three weeks, other symptoms such as hair loss, loss of appetite, general weakness, feeling unwell, internal bleeding, high fever, cataracts and temporary infertility in men may appear. If the whole body is exposed to a radiation dose exceeding 7 Sv over a period of a few days or less, the bone marrow, which produces blood cells, will be damaged and unable to produce enough cells, and death will probably occur within a few weeks. This process from the onset of symptoms to the occurrence of death depends on the radiation dose [22,28].

Regional Radiation Damage (BRH)

The effects of exposure of any area of the body to a dose of radiation over a short period of time, usually as a result of an accident, are called Localised Radiation Damage. This type usually damages the hands and fingers. The first sign of a high dose is erythema of the skin. Although it seems like a simple first-degree burn at first, the radiation burn deepens in the future and leads to bigger problems [22].

7. Delayed Effects (Chronic Irradiation Effects)

As stated above, acute irradiation occurs as a result of exposure to high doses of radiation at one time or in a short period of time. Therefore, high dose radiation exposure occurs as a result of unusual situations such as accidents or negligence. On the other hand, chronic irradiation occurs as a result of exposure to small amounts of radiation for very long periods of time. Therefore, damage caused by chronic exposure usually occurs after many years. Workers in areas with ionising radiation are thus exposed to chronic irradiation. It is difficult to measure the effect of ionising radiation in chronic irradiation by itself, since cases such as cataracts and cancer in chronically irradiated people will occur over many years. It is scientifically recognised that radiation exposure causes cancer, regardless of the amount. Since there are many and different causes of cancer in the society, it is very difficult to determine the risk of cancer due to chronic irradiation. The risk of fatal cancer due to radiological examinations is estimated according to the degree of sensitivity of each organ to radiation. For example, for every 0.1 mGy ionising radiation dose received by active bone marrow, the probability of leukaemia is 1/500000 (one in five hundred thousand). This nominal risk value is 1/200000 (one in two hundred thousand) for breast tissue, 1/500000 (one in five hundred thousand) for lung and 1/2000000 (one in two million) for thyroid [22,27,28,34].

According to the radiological protection bulletin published by the National Radiological Protection Board (NRPB) in September 2001, the lifetime

cancer development risk of each radiological examination is presented in the table below [25].

8. Conclusion

The increasing prevalence of radiation-requiring procedures such as pain therapy, the introduction of new clinical applications, and the increasing demand indicate that the risk of occupational radiation exposure for operating room technicians is increasing. Although available evidence suggests that occupational radiation doses are below the recommended threshold, for radiation-related damage There is no published definite lower limit. Even low exposure levels are not trivial. There is no published guide on radiation protection yet. Operating room technicians must comply with the "ALARA" and three basic principles, which should be considered in radiation protection, the rules of time, distance and shielding. All employees should wear protective glasses, apron, thyroid protector and dosimeter. Educational programs on the availability and correct use of protective equipment are vital to the development of safe practices. In addition, the radiation risk to be taken should be evaluated according to the benefit to be obtained from the intervention and a decision should be made accordingly.

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