

Biological Effects of X-rays on X-ray Technicians

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ABSTRACT: X-ray technicians have great risk of radiation exposure during their work. Firing electrons hit heavy metal & ionizing radiations are produced. These radiations while penetrating through living tissues can damage cells or make them abnormal. Workers who are continuously exposed even with low exposure for a long duration are prone to develop disease like skin cancer, cervical cancer, breast cancer, hair loss, eye irritation etc. The aim of this study is to find out all possible hazards in x-ray technicians and their effects on them.

In this study, in first section various x-ray hazards will be studied which have been occur since the invention of x-rays till now and their effects on various body parts and the disease associated with it.

In second section, various X-ray centres will be visited and radiographic examination of X-radiation technicians will be done of various body parts especially the chest as it tells about the positioning of heart, lungs etc. Then the X-ray films obtained will be studied to know about the all possible hazards encountered in X-ray technician and also to know the long term & short term effects of X-rays and then conclusion will be made based on the comparison with the x-ray of normal human being.

KEYWORDS: Stochastic effects, deterministic effects, dosimeter, dose rate, Thermoluminescent devices.

I. INTRODUCTION

X-radiation (composed of X-rays) is a form of electromagnetic radiation have wavelength in the range of 0.01 to 10 nanometers, corresponding to frequencies in the range 30 Peta hertz to 30 exa hertz (3×10^{16} Hz to 3×10^{19} Hz) and energies in the range of 100 eV to 100 keV [1]. X-radiations have wavelength shorter than UV rays and longer than Gamma rays. X-rays are generated when free electrons give some of their energy when they interact with the orbital electrons or nucleus of an atom. The energy given up by the electron during this interaction appears as electromagnetic energy known as X-radiation firing electrons at a heavy metal target. Bremsstrahlung process of X-ray production is the most widely used for medical and industrial applications. These ionizing radiations penetrate the living tissues and can destroy living cells or make them functionally inactive. A radiograph is a image that is produced by the passage of radiation through a subject onto a piece of film. This produces an image of the subject.

The x-rays penetrating through the human body causes changes in the molecular structure of the cell which results either in cell dysfunction(somatic effects) or mutation(genetic effects).

The workers who are over exposed to X-rays radiation are prone to disease like cancer, skin reddening etc.

II. OBJECTIVE

1. To study the all types hazards occurring in X-ray radiation and to adopt the method for their minimization.
2. To find out the x-ray hazard in x-ray technician & to analyze if any change occur from the norm.
3. Also to know whether the protective devices are being used properly or not.

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III. REVIEW OF LITERATURE

X-rays were discovered in 1895 by Wilhelm Conard Rontgen. The widespread use of x-rays led to serious injuries. Some early users suffered from skin burn due to x-ray exposure. As early as 1900, need for taking precautions was realized as an important factor. The first possible adverse effect of X-ray came from Thomas Edison, William J. Mortan & Nikola Tesla who each reported eye irritation from experimentation with X-rays & fluorescent substances. Early exposures led to loss of limbs & even lives. Studies about the effects of radiation started and users began safe working practices. In 1920s, film badges were introduced and came in to use for personnel monitoring and genetic effects were recognized.

1. The study of X-ray hazards comes under diagnostic radiology, which is mainly of two types:-

- a) Radiographic[1] :It is a picture containing film or image, which is directly sent to the computer screen.
- b) Fluoroscopic[1] : It is a real time and dynamic indication on internal functions of the body.

2. Biological Effects Occur Due To Many Reasons[2]:-

- a. Type of radiation received
- b. Size of radiation
- c. Rate at which radiation is received
- d. Part of the body exposed
- e. Age of an individual
- f. Biological differences.

3 Radiation Effects:

a. Stochastic Effects [2]: These are the effects which occur by chance and are mainly consist of cancer and genetic effects. These effects are seen years after the exposure have taken place. Chances of cancer or genetic effect increases with the increase in dose. There is no threshold defined below which the effect could be seen or any adverse effect could be seen. Stochastic effects are also called as delayed effects.

b. Non-Stochastic Effects[2]: These effects show the relationship between effect and exposure. These effects are not seen below certain threshold. These effects occur when large amount of exposure is received in short span of time and the effects could be seen within hours or days. These include erythema (skin reddening), skin & tissue burn, etc.

4. Radiation Exposure [2]:

a. Acute Exposure : Single exposure to high dose of radiation during a short period of time. It can cause stochastic or non-stochastic effects.

b. Chronic Exposure: Also known as continuous exposure, small amount of exposure is given for long term. It can cause stochastic effect which may be due inadequate or improper protective measure devices.

5. Risks associated with X-rays:

a. Cancer Risk: This is the first malignancy found due to x-ray exposure. Solid cancer risk is about 1 in 10000 and leukemia cancer risk is 1 in 100000 and the solid cancer death is about 1 in 20000.

b. Cell Radio Sensitivity: Tissues, organs or other organs are sensitive injurious action of x-ray radiation. Rate of cell division is directly proportional to sensitivity of x-ray radiation and inversely proportional to cell differentiation meaning that actively dividing cell or immature cells are affected more.

The more limiting of:

a. A total effective dose equivalent of 5 rems (0.05 Sv) or The sum of the deep-dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems (0.5 Sv).

b. The annual limits to the lens of the eye, to the skin, and to the extremities, which are:

A lens dose equivalent of 15 rems (0.15 Sv), A shallow-dose equivalent of 50 rems (0.50 Sv) to the skin or to any extremity.

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6. Various Doses Are Defined As [3]:

- a. The Shallow-dose:** Shallow dose equivalent is the external dose to the skin of the whole-body or extremities from an external source of ionizing radiation. This value is the dose equivalent at a tissue depth of 0.007cm averaged over and area of 10 cm².
- b. The Lens dose:** Lens dose equivalent is the dose equivalent to the lens of the eye from an external source of ionizing radiation. This value is the dose equivalent at a tissue depth of 0.3 cm.
- c. The Deep-dose:** Deep dose equivalent is the whole-body dose from an external source of ionizing radiation. This value is the dose equivalent at a tissue depth of 1 cm.
- d. The total effective dose:** equivalent is the dose equivalent to the whole-body.
- e. Declared Pregnant Workers:** Because of the increased health risks to the rapidly developing embryo and fetus, pregnant women can receive no more than 0.5 rem during the entire gestation period. This is 10% of the dose limit that normally applies to radiation workers. Persons under the age of 18 years are also limited to 0.5rem/year.

Table 1. X-ray Radiation Limits [3]

Body part	Single dose(mSv)	Annual dose(mSv)
Eye	2.4	49.3
Finger	1.8	90.4
Legs	0.6	21.6
Wrist	2.1	107.9

7. X-ray Radiation Protection:

Principles of Radiation Protection

The current radiation protection standards are based on three general principles:-

- a. Justification of a Practice** i.e. no practice involving exposures to radiation should be adopted unless it provides sufficient benefit to offset the detrimental effects of radiation.
- b. Protection** should be optimized in relation to the magnitude of doses, number of people exposed and also to optimize it for all social and economic strata of patients.
- c. Dose Limitation** the other hand, deals with the idea of establishing annual dose limits for occupational exposures, public exposures, and exposures to the embryo and fetus.

8. Radiation Protection Actions :

- a. Time:** Radiation dose directly proportional to time spent in the radiation.

$$\text{Dose} = \text{Dose Rate} * \text{Time}$$

If meter reads 4mR/hr, it means total dose received is 4mr for 1hr.

- b. Distance:** The second radiation protection action relates to the distance between the source of radiation and the exposed individual. This relation follows what is known as the inverse square law, stated mathematically as :

Intensity is inversely proportional to square of distance.

- c. Shielding:** Certain materials (concrete, lead) will attenuate radiation when the placed between the source of radiation and the exposed individual .More dense the material the more shielding it will provide .Lead Apron has thickness of 4mm & durability is 10 years.

9. Dose-Response Curves [3] :

- a. Linear:** The response is directly related to the dose.
- b. Non-linear:** The response is not proportionate to the dose.
- c. Threshold:** The dose at which effects are produced; below this dose, there are no obvious effects.
- d. Non-threshold:** Any dose produces a response.

10. Zero Gravity Radiation Protection System [3] :

To remove heavy weight of conventional protective device like aprons, collars, glasses etc.,this is a recent innovation. This system is made up of lead apron thicker than 0.5 mm wraparound face to protect face. This whole system is

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hanging from the ceiling and protects our whole body. The hinged arm of the system allows it to move as per the movement of technician

11. Various Protective Devices [2]:

a. Dosimeter Badge: Dosimeters are used to measure radiation exposure from gamma rays and x-rays. Because a dosimeter badge worn outside the apron would not reflect the radiation absorbed by the apron's lead, an individual monitor should be worn under the apron at the chest level, between the shoulders and waist. Badges worn on the collar can be used to estimate thyroid and lens doses. There are 2 types of personal dosimeter badges: passive and active. Passive badges can be checked after a period of time. Active badges measure radiation dose in real-time, giving radiology personnel immediate feedback regarding their exposure.

b. Radiation Monitoring: Personal monitoring is strongly encouraged for all staff who work in controlled areas where radiation exposure can occur. If a radiologic technologist or radiologist assistant finds that his or her radiation dose is too high, adjustments can be made to reduce exposure and safeguard health. If individual, personal monitoring is not feasible, radiation exposure should be measured with a passive or electronic workplace monitor, such as a dosimeter placed on the C-arm of a fluoroscopy unit.

c. Finger Dosimeter: Technologists' hands can potentially receive a high dose of radiation, particularly during procedures when they are working near the source of an x-ray or gamma ray beam. A ring dosimeter reflects the amount of radiation exposure the hands receive.

d. Pocket Dosimeter: Pocket dosimeters are used to provide the wearer with an immediate reading of his or her exposure to x-rays and gamma rays. As the name implies, they are commonly worn in the pocket. The two types commonly used in industrial radiography are the Direct Read Pocket Dosimeter and the Digital Electronic Dosimeter

e. Film Badges : Personnel dosimetry film badges are commonly used to measure and record radiation exposure due to gamma rays, X-rays and beta particles. The detector is, as the name implies, a piece of radiation sensitive film. The film is packaged in a light proof, vapor proof envelope preventing light, moisture or chemical vapors from affecting the film.

f. Thermoluminescent Dosimeter: Thermoluminescent dosimeters (TLD) are often used instead of the film badge. Like a film badge, it is worn for a period of time (usually 3 months or less) and then must be processed to determine the dose received, if any. Thermoluminescent dosimeters can measure doses as low as 1 millirem, but under routine conditions their low-dose capability is approximately the same as for film badges. TLDs have a precision of approximately 15% for low doses. This precision improves to approximately 3% for high doses. The advantage of a TLD over other personnel monitors is its linearity of response to dose, its relative energy independence, and its sensitivity to low doses. It is also reusable, which is an advantage over film badges. However, no permanent record or re-readability is provided and an immediate, on the job readout is not possible.

IV. METHODOLOGY

I visited various X-ray centres & radiographic examination of x-ray technicians has been done, then collected X-ray reports of x-ray technicians and took undertaking for completion of my research by using their reports. The study consists of 32 X-ray technicians in the age group of 20-55 years. The x-ray technicians work for 8-10 hours a day for 6 days per week. They are in the working experience of 1 to 30 years of radiation exposure. The x-ray technicians of govt. hospitals take 150 to 200 patients per day & of private hospitals 30 to 40 patients per day. X-ray technicians gives 2mSv of dose per day (i.e.,0.02mSv per patient) for chest x-ray. X-ray technicians were given an exposure of 0.02 mSv to their chest. The film obtained was studied and the report was prepared.

Dose Rate: Dose Rate of various body parts given by technicians to the patient

- Chest- 50 to 60 kV/ 20 to 30 mA
- LEG-40 to 45kV/ 8 to 12 mA
- HAND- 40 to 45kV/8 to 12 mA
- CERVICAL SPINE- 60 to 65 kV/ 30-35 mA.

I have focused on chest X-ray of X-ray technicians as it tells about the positioning of heart and lungs. Chest X-ray uses a very small dose of ionizing radiation to produce pictures of the inside of the chest. It is used to evaluate the lungs, heart and chest wall and may be used to help diagnose shortness of breath, persistent cough, fever, chest pain or injury.

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It also may be used to help diagnose and monitor treatment for a variety of lung conditions such as pneumonia, emphysema and cancer.. A chest x-ray produces images of the heart, lungs, airways, blood vessels and the bones of the spine and chest.

An x-ray (radiograph) is a non-invasive medical test that helps physicians to diagnose and treat medical conditions. Imaging with x-rays involves exposing a part of the body to a small dose of ionizing radiation to produce pictures of the inside of the body. X-rays are the oldest and most frequently used form of medical imaging. The chest x-ray is performed to evaluate the lungs, heart and chest wall. A chest x-ray is used to help diagnose symptoms such as Breathing difficulties, a bad or persistent cough, chest pain or injury, fever.

Physicians use the examination to help diagnose or monitor treatment for conditions such as:

Pneumonia, Heart failure and other heart problems, Emphysema Lung cancer positioning of medical devices, fluid or air collection around the lungs and other medical conditions.

V. RESULT

Based on the previous studies, people exposed to higher doses of radiations have greater risk of life threatening disease like cancer. Stochastic effect is the result of improper or inadequate protective measures. Technicians are suffering from skin irritation, pain in the body, hair loss, high blood pressure. In this study it is found that most of the technicians are in the protective exposure limit by taking protective measures like lead apron TLD. One among the various technicians is facing weakness in the eyes because of not using Lead glasses.

VI. CONCLUSION

X-rays are harmful if one is exposed for a long time and effects associated are stochastic effects. If an individual frequently undergo x-ray examination of higher doses then deterministic effects are seen like hair loss , skin burn. As the study was small, so no malignancy is found in the technician. As the technicians are not much aware about the recent protective measuring devices and safety controls they are facing problems like hair loss, weak eyesight. As the study was carried out on less number of patients, so in this group of patients no malignancy is found in this particular group of technicians because of X-rays.

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