The Effect of X-Ray Radiationon Hematopoietic Tissue Among Radiology Technologists

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Abstract: Background:Long-term exposure to low doses of ionizing radiation may affect cells and tissues and results in various adverse health effects**.** Objectives**:**In this study the purpose is to detect the blood cells count which reflects of the changes that may happen in bone marrow of X-ray technologists.Materials and Methods:The present study is conducted in Khartoum state hospitals during the year of 2011. The sample size was 95 male volunteers represented radiology technologists working in Khartoum state hospitals with age range 23-57 years.Technologists are classified according to duration of exposure.The samples are tested for hematology parameters by cell counter. Results:The mean value of leucocytes, neutrophil and lymphocyte count is significantly decreased ($p<0.05$) in X-ray technologists on duration of exposure between 10-15 years, while X-ray technologists on duration of exposure greater than15 years showed significant decrease ($p<0.01$) when compared to controls. However, no significant difference is observed in red blood count, hemoglobin, and mean cell volume, mean cell hemoglobin, mean cell hemoglobin concentration, hematocrit and eosinophil + basophil count between the groups.Conclusion:Hematopoietic system of X-ray technologist is affected by long duration of low dose of X-ray exposure resulting in depression peripheral white blood cells count particularly that of neutrophil and lymphocyte.[Waggiallah HA. NJIRM 2013; 4(2) : 16-20]

Key Words: Hematopoietic tissue, hematology parameters, X-ray, X-ray technologists.

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Introduction: X-radiation (composed of X-rays) is a form of electromagnetic radiation. X-rays have a wavelength in the range of 0.01 to 10 nanometers, corresponding to frequencies in the range 30 petahertz to 30 exahertz (3×1016 Hz to 3×1019 Hz) and energies in the range 100 eV to 100 keV. They are shorter in wavelength than UV rays and longer than gamma rays. In many languages, X-radiation is called Röntgen radiation.[1] Hard X-rays can penetrate some solids and liquids, and all uncompressed gases, and their most common use is to image of the inside of objects in diagnosticradiography and crystallography.[2]Radiographs obtained using X-rays can be used to identify a wide spectrum of pathologies. Because the body structures being imaged in medical applications are large compared to the wavelength of the X-rays, the X-rays can be analyzed as particles rather than waves. The making of an X-ray image of human or animal bones, short X-ray pulses illuminate the body or limb, with radiographic film placed behind it. Any bones that are present absorb most of the X-ray photons by photoelectric processes. This is because bones have a higher electron density than soft tissues.[3]

Diagnostic X-rays increase the risk of developmental problems and cancer in those exposed. [4] X rays are classified as a carcinogen by both the World Health Organization's International Agency for Research on Cancer and the U.S. government.[5] Workers over exposed to X-ray radiations are prone to develop life-threatening diseases often related with hematopoietic system. In view of the fact that, the hematopoietic system is highly sensitive to radiation and the peripheral blood count may well serve as a biological indicator of such damage.[6]The exact effect depends on the magnitude of the exposure. Everyone receives a certain amount of radiation from "background exposure". For most people that amounts to 100-300 milliRems of radiation. The "mean fatal dose" of full body exposure to ionizing radiation is approximately 500-600 Rems. Federal regulations permit workers in radiation to be exposed to a maximum of 5 Rems each year.[7] Thus, the present study bone marrow suppression is expected in these technologists.

Materials and Methods: The present study is conducted in Khartoum state hospitals during the year of 2011. The sample size is 95male volunteers represented radiology technologists working in Khartoum state hospitals with age range 23-57 years. These X-ray technologists work in different shifts for 8 hours a day for five days per week. Subjects with chronic systemic disease such as renal failure or hear disease, chronic viral infection and smokers are excluded from this study.95volunteers apparently healthy are selected as control group with a similar manner to that of the X-ray technologists.

Ethical approval: Permission from the ethical committee of AlneelainUniversity, Khartoum state hospitals managements are taken and verbal consent from study subjects on explanation of study objectives.

Sampling: Blood samples used in this study are drawn using vacutainer system into heparin and EDTA anticoagulant.

Sample preparation: The heparinized, and EDTA samples arelabelled by serial number and the date of collections were noted.

Samples are mixed well and tested within one hour for full blood count; red cell count (RBCs), hemoglobin (HGB) concentration, mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), hematocrit (HCT), white blood cells (WBCs) count, neutrophil, eosinophil, basophil, lymphocyte, monocyte and platelet count,the samples are tested4 times during the study period for complete blood countusing blood cell counter (SysmexCompany) Japan.

Statistical analysis: Data are analyzed statistically using student t-test to see if there is any significant difference between the mean of patients and the mean controls results

Results: The comparison of hematology parameters in X-ray technologists on the basis of duration of exposure 10-15 years are demonstrated in table 3. There are significant differences between the means values of WBCs, neutrophil, and lymphocytes count in X- ray technologists group ($p < 0.05$).

The comparison of hematology parameters in X-ray technologists on the basis of duration of exposure > 15 years are demonstrated in table 4. There are significant differences between the means values of WBCs ($p < 0.001$), neutrophils ($p < 0.05$)and lymphocytes ($p < 0.001$) count in X-ray technologists group.

Table1. Shows hematologyparameters (Means ± SD) between X-ray technologists on duration of exposure < 5 years compared with normal Controls (n= 19).

Parameters	Units	Control Subjects	X-ray technologists
RBCs count	10^{12}/L	5.3±0.08	4.9±0.14
HGB	g/L	146 ±2.2	129±4.5
HCT	L/L	44.3±2.27	42.1±1.27
MCV	Fl	92.1±1.17	90.9±2.07
MCH	Pg	31.9±0.28	32.7±0.44
MCHC	g/L	33.8±0.34	31.4± 0.37
WBCs	10^9/L	6.4±0.223	5.8±0.45
Neutrophils	10^9/L	2.76±0.01	2.4±0.06
lymphocyte	10^9/L	1.38±0.003	1.11±0.006
Monocytes	10^9/L	0.368±0.009	1.29±0.005
Mixed cells	10^9/L	0.092±0.0023	1.00±0.0061
Platelets	10^9/L	254.4±1.19	247.9± 2.08

Table2.Shows hematologyparameters(Means ± SD) between X-ray technologistson duration of exposure between5-10 years compared with normal Controls (n= 28).

Parameters	Units	Control Subjects	X-ray technologists
RBCs count	10^{12}/L	4.9±0.4	4.5±0.3
HGB	g/L	138±3.1	131±2.9
HCT	L/L	41.3±1.1	39.2±2.6
MCV	Fl	88.1±3.7	89.9±4.1
MCH	Pg	28.9±1.7	29.7±2.9
MCHC	g/L	34.8±2.5	30.1±1.8
WBCs	10^9/L	5.5±0.6	4.9±0.3
Neutrophils	10^9/L	3.01± 0.1	2.6±0.07
lymphocytes	10^9/L	1.08± 0.002	1.30±009
Monocytes	10^9/L	1.01±0.06	0.90±0.02
Mixed cells	10^9/L	0.40±0.003	0.1±0.001
Platelets	10^9/L	301.3±10.8	297.1±13.0

Table 3.Shows hematology parameters (Means ± SD) between X-ray technologistson duration of exposure between10-15 years compared with normal Controls (n= 31).

Parameters	Units	Control Subjects	X-ray technologists
RBCs count	10^{12}/L	5.1±0.6	4.7±0.9
HGB	g/L	137± 12.1	125± 11.7
HCT	L/L	43.3± 3.1	37.1± 2.8
MCV	Fl	89.4± 2.7	87.9± 3.9
MCH	Pg	30.6± 1.6	27.1± 1.9
MCHC	g/L	33.0± 3.7	29.1± 1.8
WBCs	10^9/L	6.6±0.8	3.01*±0.3
Neutrophils	10^9/L	3.67± .09	1.01*±0.02
Lymphocyte	10^9/L	1.08±0.044	0.10* ±0.0081
Monocytes	10^9/L	1.00±0.071	0.95±0.0099
Mixed cells	10^9/L	0.85±0.009	0.95±0.0076
Platelets	10^9/L	220.8± 10.9	217.1± 17.9

* p< 0.05

Table 4: Shows hematology parameters (Means ± SD) between X-ray technologistson duration of exposure>15 years compared with normal Controls (n= 17).

Parameters	Units	Control Subjects	X-ray technologists
RBCs count	10^{12}/L	5.4±0.89	4.5±0.65
HGB	g/L	139± 17.4	111± 10.9
HCT	L/L	44.2± 2.3	35.1± 3.5
MCV	Fl	91.4± 4.1	87.3± 2.99
MCH	Pg	28.6± 2.01	26.1± 1,09
MCHC	g/L	30.2± 1.08	28.1± 2.08
WBCs	10^9/L	6.9±0.4	2.90**±0.09
Neutrophils	10^9/L	3.07±0.1	1.00*±0.0023
Lymphocytes	10^9/L	2.07±0.03	0.11**±0.005
Monocytes	10^9/L	1.70±0. 021	1.75±0.043
Mixed cells	10^9/L	0.06±	0.04±0.0087
Platelets	10^9/L	269± 9.7	259.8± 8.04

* p< 0.05 ** p < 0.001

Discussion: Hematopoietic system is affected by long duration of low dose of X-ray exposure resulting in peripheral blood cells count. In this study the purpose was to detect the blood cells count which is reflect of the changes may happen in bone marrow of X-ray technologists.

The basic radiation-matter interaction for ionizing radiation in the therapeutic energy range consists of Compton scattering of an x-ray photon and an orbital electron. Subsequent interactions result in deposition of energy by the scattered electron in critical "target sites" in the cell. These are generally believed to be interactions with DNA.Technologists over exposed to X-ray radiations are prone to develop life-threatening diseases often related with haematopoietic system such as leukemia and aplastic anemia. At the cellular level there remain many gaps in the knowledge of mechanism of radiation injury. Theoretical models based on microdosimetric considerations and on DNA breakage[8].

In this study in table 3 we observed significant (p < 0.05) reductions of leucocytes count particularly neutrophils and lymphocytes, because white blood cells are only nucleated cells in blood stream and contain DNA, so the effect of long –term exposure of X-ray will be more significant as shown in table 4 (p < 0.001), so the duration of exposure of X-ray and time factor are crucial in reduction of leucocytes.

In one of the earlier studies on the effects of in vitro radiation on leucocytes, Sokolov [9] demonstrated that X-ray doses of 90 Gy1, caused the leukocyte count to drop by 30 per cent when measured one day following irradiation. In an electron microscope study of X-ray damage to frog blood cells, Lessler andHerrera [10] reported that following 10 Gy, there was increased vacuolization of the leukocytecytoplasm. While granulocytes are generally more radiation resistant than lymphocytes, they are less so than earlier studies had indicated, and there may therefore be some loss of granulocytic functional activity at long exposure.

Valerius et al. [11] suggested that a 20 Gy radiation dose is likely to eliminate lymphocyte mitotic ability, without significantly damaging granulocytes.

Hryceket al[12] reported that workers handling X-ray equipment have disturbances of peripheral blood neutrophil metabolism. In addition, they also observed that neutrophil phagocytic activity was weakened in persons working over five years with X-ray equipment.

Rozgajet al [13] reported that the blood count drops soon after irradiation and recovers within several weeks. Our results for the drop of leucocytes (lymphocyte and neutrophil) count confirms the results observed by Rozgajet al.

Nothdurftet al [14] reported that ionizing radiation is one of the cytotoxic agents that particularly cause damage to cell renewal systems. They also demonstrated that the lymphocytes andneutrophilic granulocytes uniformly showed early decrease within the first days corresponding to cumulative radiation doses.

Mature non-nucleated erythrocytes, in comparison to other blood components, would appear to be relatively resistant to radiation damage as presented in our results.

Sokolov [9] reported that there was no decrease in the number of red blood cells following doses of X-rays of up to 97 Gy, hemolysis was evident at doses greater than 60 Gy.

In X-irradiated in vitro suspensions of erythrocytes at concentrations of 0.5 to 5 percent, hemolysis was independent of the suspending medium. However, at cell concentrations of less than 0.5 percent, hemolysis was dependent on the type of suspending medium [15].

As per obtained result, the above values of platelet count have shown no significant change. Aggregation and release responses of platelets and expression of platelet - factor 3 were not influenced by a 50 Gy radiation dose [16]. Similarly, Coif man et al [17] reported that platelet survival is not appreciably affected by a 50 Gy radiation dose. In fact,irradiation of platelets even at 750 Gy, in vitro, produced no significant damage [18].

Conclusion: Long-term exposure of low dose of X-ray affected the leucocyte count (neutrophil and lymphocytes). The significant decrease in leucocytes can be translated in clinical benefits for occupational health of X-ray technologists to adopt technical preventive measures such as wearing appropriate protective equipment, like lead apparel, lead goggles etc. X-ray technologists should regularly use appropriate personal protective equipments at their work site. These measures will help to prevent the hazards of X-ray radiations.In addition; X-ray technologists must undergo pre-employment and periodic medical surveillance tests to identify the more susceptible workers. It is also suggested that after every three months short term leaves should be granted for X-ray technologists to minimize the exposure effect of X-ray radiation.

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