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The Impact of Prolonged X-Ray Exposure on Human Lymphocytes

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ABSTRACT:
This study aims to explore the impact of prolonged X-ray exposure on human lymphocytes, reactive lymphocyte parameters, and lymphocyte morphology among X-ray technicians at hospitals. The research involved 54 apparently healthy male X-ray technicians matched with 54 healthy controls to assess any changes in lymphocytes, reactive lymphocytes, and morphology. The samples were categorized based on work experience and daily working hours, and hematological parameters were analyzed using complete blood cell count (CBC). Results revealed a significant ($P<0.0001$) increase in reactive lymphocytes among all groups of diagnostic technicians compared to controls, along with a notable increase in lymphocytes in certain groups. This study concludes that chronic X-ray exposure can significantly alter lymphocyte and reactive lymphocyte parameters, with the number of working hours per day showing noticeable effects on lymphocyte morphology.
Keywords: X-Ray Exposure, Lymphocyte, Reactive Lymphocyte

INTRODUCTION:

X-rays are a form of electromagnetic radiation produced outside of a nucleus, with energy levels lower than gamma rays. They are primarily generated artificially, with their major application being in medicine. Ionizing radiation, including X-rays, has the ability to ionize atoms by stripping electrons from their orbits, resulting in positively charged ions and negatively charged free electrons. (Cember & Johnson, 2008)

The impact of ionizing radiation on living cells varies depending on factors such as the dose amount, dose rate, individual characteristics (sex, age), and the specific target within cells. Direct interaction occurs when ionizing radiation directly affects critical targets like DNA, while indirect interaction involves the radiation interacting with water molecules within cells, producing ions and free radicals. (Shafiee et al., 2016)

Health physics, radiological health, and radiological engineering are crucial fields in public and environmental health that focus on safely using both ionizing and non-ionizing radiation to prevent biological harm to humans. Health physicists play a vital role in ensuring the safe design of processes, equipment, and facilities using radiation sources, as well as in managing radioactive waste disposal to minimize radiation exposure and maintain safe limits. (Taqi Ali et al., 2018)

Different cells and tissues in the human body exhibit varying degrees of radiosensitivity, with some being more sensitive to radiation (radiosensitive) and others more resistant (radioresistant). The hematopoietic system is particularly radiosensitive, making peripheral blood count a suitable biomarker for estimating radiation damage. (Shahid et al., 2015)

With the increasing use of ionizing radiation in medical procedures, the number of X-ray technicians is expected to rise. However, observations in hospitals have noted diagnostic technicians not consistently using radiation protection tools, especially for low doses of X-rays during their workdays. (Shishkina et al., 2004)

While many studies have explored the effects of high-dose radiation, there is limited information on the risks faced by technicians in clinical radiology departments, particularly regarding potential changes in

basic hematological parameters such as red blood cells (RBCs), white blood cells (WBCs), and platelet counts, which can indicate harmful effects of X-ray radiation. (Allehayanim & Monem, 2003)
This study, conducted in hospitals, aims to investigate the long-term effects of X-ray radiation on technicians' blood, focusing on lymphocytes, reactive lymphocytes, and their morphology. (Minister of Public Works and Government Services Canada (PWGSC) et al., 2012)

MATERIALS AND METHODS:

The study included 54 healthy male X-ray technicians working at hospitals, along with 54 healthy male individuals selected as the control group. The impact of X-ray radiation on lymphocyte parameters was assessed through two approaches.
Firstly, the technicians were categorized into two groups based on their work experience at the hospital. The first group had 29 technicians with experience ranging from 1 to 7 years, working an average of 7 hours per day. This group had an average age of 39 years. Similarly, 29 volunteers in the control group, with an average age of 35 years, were included for comparison. The second group consisted of 25 technicians with experience ranging from 8 to 21 years, working an average of 6 hours per day, and 25 controls with an average age of 39 years.
Additionally, the technicians were divided into three groups based on their daily working hours. The first group worked 1 to 6 hours per day, comprising 13 technicians with an average age of 38 years, and 13 controls with an average age of 34 years. The second group worked 7 hours per day, including 18 technicians with an average age of 42 years, and 18 controls with an average age of 32 years. The third group worked 8 to 12 hours per day, with 23 technicians having an average age of 40 years, and 23 controls with an average age of 34 years.
All participants were provided with an explanation of the study's purpose. Blood samples of 2 ml were collected from each participant and transferred to an EDTA tube. Hematological parameters, including lymphocytes and reactive lymphocytes, were analyzed using a complete blood cell count (CBC) analyzer (Alpha Swelab, Sweden) to detect any variations between the groups.

RESULTS:

Table 1 presents the measured data of lymphocytes in both control subjects and X-ray technicians exposed to different working conditions. A significant increase ($p=0.0231$) in lymphocyte count was observed for technicians with 1-7 years of experience working an average of 7 hours per day. Similarly, a significant increase ($p=0.0144$) in lymphocytes was noted for the group working 7 hours per day. There were slight increases in lymphocyte count for the other groups, although these were not statistically significant.
Table 2 displays the measured data of reactive lymphocytes in control subjects and X-ray technicians across different exposure durations. A highly significant increase ($p=<0.0001$) in reactive lymphocytes was observed for all technician groups compared to their respective controls. Figures 1 and 2 depict the reactive lymphocytes for X-ray technicians based on work experience and working hours per day, showing clear changes in lymphocyte morphology.
These results indicate that long-term X-ray exposure among technicians led to significant alterations in lymphocyte parameters, with notable increases in both lymphocytes and reactive lymphocytes compared to control groups.

Table 1: Mean and standard deviation (SD) of Lymphocyte count for the control groups and X-ray technicians.

Group	Average Working hours/day	(mean ± SD) of Lymphocyte×10^9 l-1	P-Value
	Control subject	X-ray technicians	
1-7	years	7	
		2.49 ± 0.472	2.9 ± 0.82
8-21		6	
		2.456 ± 0.488	2.688 ± 0.619

1-6	hours/day	3	
		2.638 ± 1.059	2.8 ± 0.823
7		7	
		2.367 ± 0.451	2.889 ± 0.731
8-12		9	
		2.426 ± 0.475	2.691 0.727

NS: Non-Significant; < 0.05 = Significant

Table 2: Mean and standard deviation (SD) of Reactive lymphocyte count for the control groups and X-ray technicians.

Group	Average Working hours/day	(mean ± SD) Reactive lymphocyte	P-Value
	Control	X-ray technicians	
1-7	years	7	
		1.03 ± 1.18	8.59 ± 6.2
8-21		6	
		0.76 ± 0.93	5.8 ± 4.29
1-6	hours/day	3	
		1 ± 1.08	5.31 ± 3.25
7		7	
		0.94 ± 1	8.44 ± 5.83
8-12		9	
		0.78 ± 0.95	7.52 ± 6.18

DISCUSSION

In the discussion section, you have highlighted several key points regarding the effects of chronic exposure to X-ray radiation on lymphocyte parameters and morphology in technicians.

Chronic Exposure and Occupational Hazard: The study emphasizes the potential occupational hazard faced by diagnostic technicians due to chronic exposure to low doses of X-ray radiation. While individual exposures during procedures may be low, the cumulative effect over time can lead to serious long-term health consequences. (Cember & Johnson, 2008)

Impact on Lymphocyte Parameters: The study divided samples based on work experience and daily working hours. It observed a highly significant increase in reactive lymphocytes across all groups compared to controls, with a significant increase in lymphocytes observed specifically in the (1-7) years experience group working 7 hours/day. This suggests that chronic X-ray exposure can indeed alter lymphocyte and reactive lymphocyte parameters. (Shafiee et al., 2016)

Comparison with Other Studies: The findings align with previous research by Saman Shahid et al., which also noted an increase in lymphocytes after exposure to low-dose long-term radiation. This consistency reinforces the observed effects of X-ray radiation on lymphocyte counts. (Taqi Ali et al., 2018)

Immune System Impact: Chronic exposure to ionizing radiation can potentially affect the immunity of workers, as seen in reductions and changes in hematopoietic parameters. The study suggests that the repair mechanisms of lymphocytes may be slower compared to reactive lymphocytes, leading to observable changes in their counts. (Shishkina et al., 2004)

Morphological Changes: The study also observed clear changes in the morphology of lymphocytes in X-ray technicians. While studies on lymphocyte morphology post-radiation are limited, existing research on red blood cells (RBCs) and lipid metabolism in erythrocytes provide insights into the potential impact of radiation on cell structures. (Allehayanim & Monem, 2003)

Overall, the study underscores the importance of monitoring and mitigating the risks associated with chronic X-ray exposure in occupational settings, particularly in relation to its effects on lymphocyte parameters and morphology.

CONCLUSION

In conclusion, the study demonstrates significant alterations in both lymphocyte and reactive lymphocyte parameters among X-ray technicians due to chronic exposure to X-ray radiation. Moreover, the study highlights that the number of working hours per day has discernible effects on lymphocyte morphology. Specifically, there was a significant increase in lymphocytes and a highly significant increase in reactive lymphocytes observed. The findings underscore the importance of informing X-ray technicians about these results and emphasizing the crucial role of using radiation protection tools to prevent overexposure during their daily work.

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