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RESEARCH ARTICLE

EFFECT OF COMPUTED TOMOGRAPHY (CT) SCAN EXPOSURE ON HEMATOLOGICAL PARAMETERS

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Abstract

Background and aims: CT scan is more used in diagnosis; however, this examined was delivered a low dose estimated approximately to 50 mGy. In this study, the impact of CT scan exposure on hematological parameters for Congo-Brazzaville patients was analyzed.
Methods: Blood samples have been obtained from 61 patients including 23 young patients (<17 years). Blood sample was obtained before and 24h after CT-scan exposure from three different hospitals Congo-Brazzaville. 30 healthy donors have been included as a control. Hematological parameters have been analyzed using software.
Results: Significant decrease of red blood and hemoglobin were observed after 24 h of CT scan exposure for all patients (p=0.0002 and p=0.0004 respectively). Significant increase of white blood and granulocyte were observed only in adult patients (p=0.0057 and p=0.011respectively). Significant correlation was observed between the Abdominal-Pleven CT-scan and the variation of white blood and granulocytes. Interestingly, decrease of lymphocytes was observed in adult patients and lymphocyte increase was detected in young patients.
Conclusion: We were demonstrated for the first time the variation of hematological parameters after exposure to be very lower doses such as CT-Scan doses. These variations could be reflected inflammatory reactions. Additional analysis can be performed for the validation of these data using a large cohort.
Keywords: CT-Scan, hematological parameters, low-dose exposure, young patients.

INTRODUCTION

The introduction of ionizing radiation in medical field has been revolutionized not only the detection of diseases but also the therapeutic management of patients[1]. CT scan is the most used radiological exams in diagnosis allowing a higher precision in the detection of the diseases[2]. Nevertheless; CT-scan was delivered a low-dose of ionizing radiation, approximately 50 mGy. Epidemiological studies and physics dosimetry are generated sufficient knowledge concerning the absorbed dose after CT scan and the risks were associated to these exposures in general population and especially in children[3]. In case of accidental exposure with higher doses, three exams are recommended: hematological exams, cytogenetic investigations and biochemistry analysis. A large literature concerns these three pillars of biological dosimetry after higher dose exposure is very well established. However, the impact of a very low-dose exposure such as CT scan still was debated and significantly controversy[4]. The impact of low-dose exposure in hematological parameters has not been performed until now[5]. In this study, hematological parameters have been investigated in children and adults before and after 24h after CT-Scan exposure. We were demonstrated for the first time the decrease of hemoglobin and reed blood in children and adults after CT-scan. In adult, a significant increase of white blood and granulocyte was observed.
All these data demonstrate clearly that CT scan exposure was induced an inflammatory reaction.

SUBJECTS AND METHODS

Total 61 patients who were exposed to CT scan for diagnosis in three different hospital centers (Mfilou; Blanche Gomes et Talangai). They were 27 males and 34 females with a men age of 29 (range 7-70 years) (Table 1A). None of these patients had been exposed to ionizing irradiation. 30 healthy donors with mean age 26 (range 8-55 years) (Table 1A) and 1 M/F ratio have been used as a control. Blood samples were obtained before CT-scan and 24 hours after. For healthy donors, similar sample protocols have been performed. Hematological parameters have been analyzed using diagnosis protocols. All patients and healthy donors gave their informed consent. This study was performed in accordance with local ethical rules (N° 398/ MESRSIT/IRSSA-CERSSA). Used sample of healthy donors has an average age of 26 years.

Table 1A: Distribution of patients by age.

Age group	Workforce (%)
7–19	20 (21.74)
20–33	25 (27.17)
34–46	08 (8.7)
47–59	14 (15.22)
60–72	03 (0.02)
Total	92 (100)

CT scan exposure

Patients have been exposed to three kind of CT-scan (Siemens and Neusoft) in the helical mode with or without contrast medium (OMNIPAQUETM, IOHE XOL). The dose can be quantified by two dosimetric quantities: computed tomography dose index and dose length product. In addition, the sensible dosimeter (RAYSAFE, X2/Ref.82310106, SWEDEN, SN2837 77, was calibrated, was placed next to the patient to collect the absorbed doses by the skin patient. Three types of CT scans have been performed according to their availability in different hospitals: Cerebral, Thoraco-Abdominal, Thoraco-Abdominal-Pelvienne.

Table 1B: Distribution of healthy donors by age.

S.N.	Ages of healthy donors	Workforce
1	8	02
2	9	01
3	10	02
4	12	01
5	16	03
6	17	01
7	20	03
8	21	01
9	23	02
10	24	02
11	26	01
12	30	02
13	32	01
14	33	01
15	37	01
16	39	01
17	42	01
17	45	01
18	50	01
19	55	02
	Total	30

Hematological parameter analysis

The blood study was performed by the Blood Count technique using EDTA-K3 tubes then was passed to the automated machine. From this homogenate, 2 to 5 µL are sucked in and then passed to the analyzer, before the scan. The examination was repeated 24 hours later to confirm the changes in the hematological parameters of the blood cells. The hematology machine was used to count the number of blood elements. The automated system was used to analyzing the blood collected from the patients, allowing the detection of abnormalities of the three blood lines. Analyses were performed by the automaton for the collection of hematological parameters: red blood cells or erythrocytes, white blood cells or leukocytes, platelets or thrombocytes.

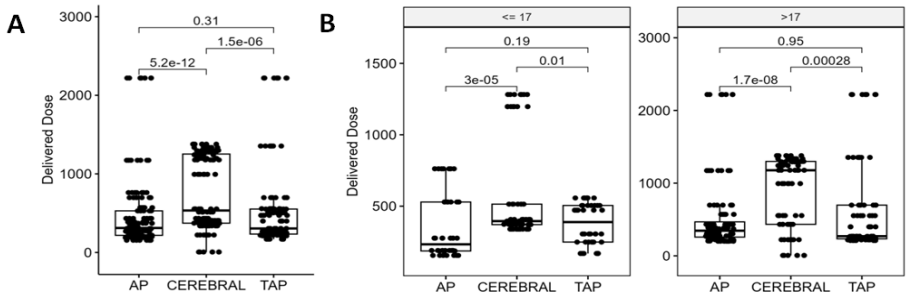

Figure 1: Repartition of the delivered dose by CT-scan.

Statistical analysis

All statistical tests are done with R v4.3.0; the non-parametric Wilcoxon was runk sum test is from the ggpubr v0.6.0 library.

RESULTS AND DISCUSSION

Repartition of the delivered dose by CT-scan

The DPL and CTDI was delivered by CT-Scan are showed in Figure 1. No significant difference was observed between the calculated dose with or without contrast compound. However, significant difference for the delivered doses was observed between the type of CT scan (Figure 1A). The pediatric patients was received a reduced dose compared to adult patients (Figure 1B).

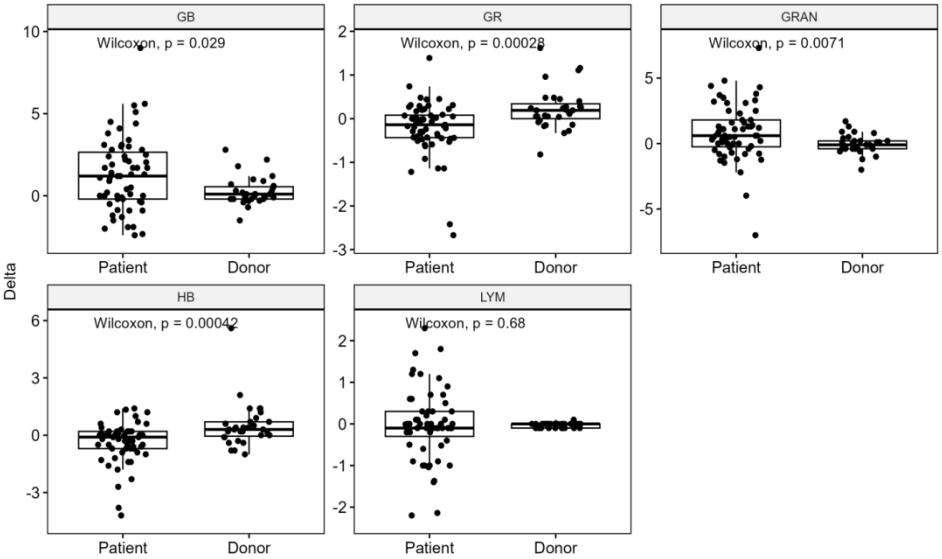

Figure 2: Variation of hematological parameters in patients 24 h after CT-Scan exposure.

Comparison avec ICRP

Figure 2 is showed the variation of hematological parameters in patients 24 h after CT-Scan exposure was compared to control population was sampled in the same conditions. Significant decrease of red blood and hemoglobin were observed in all patients compared to controls (p=0.00028 and p=0.00042 respectively). Nevertheless, significant increase of white blood and granulocyte were observed in patients compared to controls (p=0.029 and p=0.0071 respectively). In addition, no significant difference was observed in the level of lymphocytes between patients and controls. However, a higher inter-individual variation has been observed (Figure 2). Next, we have been analyzed the impact of the type of CT-Scan for these hematological exams. Figure 3 is showed the correlation between the type of CT-scan and the variation of hematological parameters. Significant decrease of red blood and hemoglobin were observed after different type of CT-Scan. Similar correlation was obtained regarding the increases of granulocytes and all type of CT-Scan. However, only significant correlation was obtained between AP CT Scan and white blood.

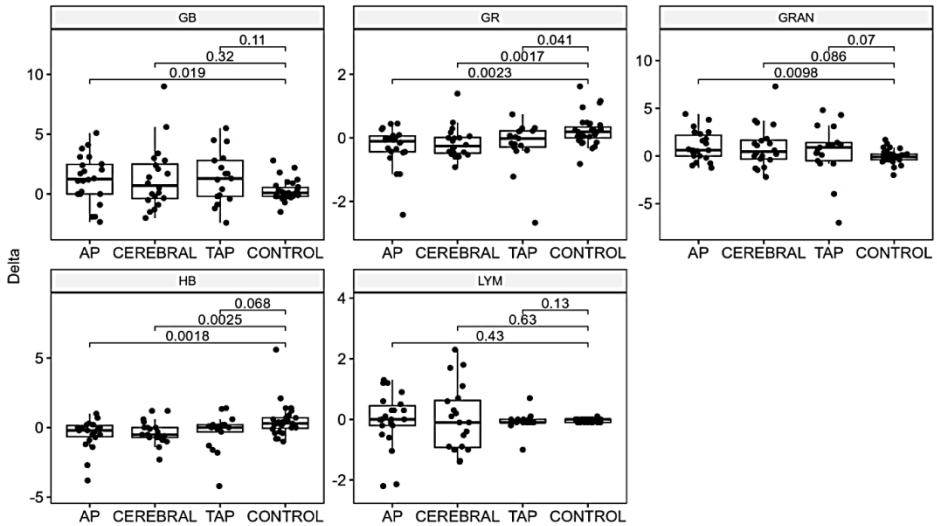

Figure 3: Correlation between the type of CT-scan and the variation of hematological parameters.

Variation of hematological parameter age depends

Regarding the higher inter-individual variation, we have been analyzed the variation of hematologic parameters in young patients (<17 years) and adult patients (>17 years). Figure 4 is showed the impact of CT scan on the hematological parameters for these two groups. The study has been confirmed the significant increase in red blood and hemoglobin for young and adult patients. However, significant increases in white blood and granulocyte were observed only in adult patients. As far as the variation of lymphocytes is concerned, we were observed the different variation between young and adult patients. Increases of lymphocyte counts were detected in young patients and decreases in adult patients. Next, we have been analyzed the impact of age and type of CT-Scan on hematological parameters. Between the variation of white blood, granulocyte and hemoglobin and the thorax abdominal pelvic CT-Scan in adult patients, significant different was observed.

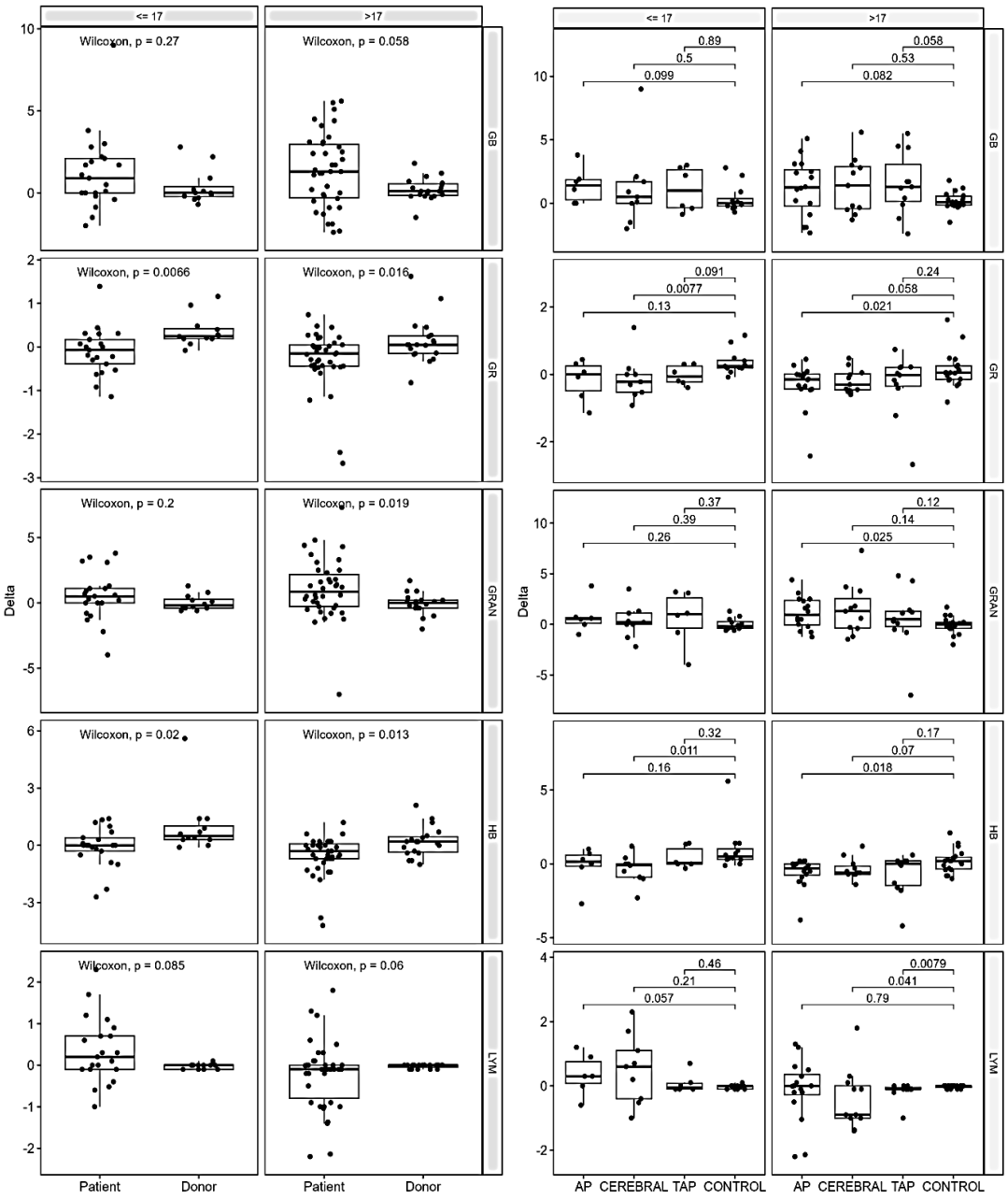

Figure 4: Impact of CT scan on the hematological parameters.

For young patients, only white blood was correlated to thorax abdominal pelvic CT-Scan. Concerning the lymphocytes variation, the significant correlation was observed between Cerebral CT-Scan for adult and abdominal pelvic CT scan for young patients. Human cells and tissues of volunteer patients can be affected due to long-term exposure to low-doses of ionizing radiation, particularly on peripheral blood cell counts[6]. This study is investigated the hematological effects and susceptibility in individuals who have been exposed to low-dose ionizing radiation, specifically patients and controls in Congo-Brazzaville. The study was recruited patients and controls, all volunteers, who were exposed to ionizing radiation which usually comprises X-rays. The study were used a sampling method that involved a survey of volunteers who were patients or controls and were exposed to radiation in the Mfilou, Branche Gomes, and Talangai hospitals in Congo-Brazzaville. The researchers were obtained 61 patients and 31 controls. It is well established that ionizing radiation has been documented effects on blood cells, which are believed to causing the hematopoietic syndrome, were observed in patients and case/control subjects, were exposed to body radiation. Exposure to lower doses of ionizing radiation a common occurrence in certain work places. Radiological accidents, although unfortunate and potentially devastating, will be continuous to occur. Thankfully the majority of radiation exposures are involved low-doses (<1 Gy) and therefore do not be had an immediate fatal impact. Nevertheless, the potential long-term effects of low-dose should be considered seriously[7]. Based on the magnitude of the decrease and the time was required to showing a significant decrease in blood cell count after irradiation, white blood cells were appeared to being the most sensitive among the cell types were assessed in response to X-ray irradiation[8]. The damage was caused by ionizing radiations can be lead to a

significant and dose-dependent reduction in the number of blood cells, which could be considered a potential health risk during exposure. Rozgaj *et al*., previously were reported that long-term exposure to be lower doses of ionizing radiation could be affected cells and tissues, resulting in low blood counts soon after irradiation and recovery within weeks. The decrease in the number of leukocytes are confirmed the findings are identified in the blood test formula[9]. Seed and al were reported that ionizing radiation is one of the cytotoxic agents that specifically harm cell renewal systems. They were also demonstrated that lymphocytes and neutrophil granulocytes experienced a consistent decline in the initial days that corresponded to cumulative radiation doses[10].

To sustain cell replication and system homeostasis, a proliferating cell system needs an intact cell type, the stem cell, and early progenitor cells. All cells can be affected following irradiation, whether acute or chronic, with stem cells and early progenitor cells being among the most radiosensitive. At relatively low-doses or dose-rates, hundreds of stem and progenitor cell clones can be emerged each showing individual damage, as expected from a damaged cell. These cell is cloned supply a wide range of proliferating cells, possibly including the abnormal cell populations[11]. Because of the exceptional variety of cell type, proliferative capacity, and cell cycle stage in the bone marrow, it has been investigated by four researchers that some subpopulations of stem cells or other cell types in the marrow microenvironment are able to resisting radiation damage. In this study, white blood cell counts were showed a significant reduction 24 hours after irradiation at all dose levels were compared to the control group, with the number of white blood cells were being affected at a dose of 0.3 Gy. The magnitude is increased as the dose increases. This finding is in agreement with a previous study which was observed a statistically significant decrease in leukocyte count hours after radiation exposure in all doses except the 0.25 Gy group[12]. Damage to hematopoietic stem cells is the primary cause of mortality resulting from accidental or intentional exposure to moderate or high. Exposure to radiation has been shown to damage hematopoietic stem cells and generate several types of free radicals in living cells. Free radicals/reactive oxygen species have been found to induce apoptosis of hematopoietic cells, thereby decreasing their ability to proliferate. This is likely to occur as the hematopoietic system is highly sensitive to radiation. This system is responsible for blood clotting in blood vessels[13]. According to Figure 2, red blood cell and hemoglobin levels were significantly lower in radiation-exposed patients than in controls, while white blood cells and granulocytes were significantly higher in radiation-exposed patients than in controls ($p<0.05$). In a previous study, it was noted that patients exposed to radiation had been higher levels of red blood cells and lymphocytes[12]. Radiation exposure more easily and sensitively is changed the hematological parameters of patients, except for red blood cells and monocytes Stem cells are highly radiosensitive, although mature platelets are less sensitive to ionizing radiation. As a consequence, patients have been lowed platelet counts compared to case/control subjects. A mild or moderate IR dose typically is caused a platelet count reduction 5 to 10 days after exposure. The length of time thrombocytopenia persists is directly related to the dose of ionizing radiation and to the usage of platelets at active bleeding sites. This is due to non-hematological complications of IR exposure like gastrointestinal lesions and trauma[14].

A study was showed that there was a reduction in the number of platelets after irradiation, particularly at 0.5 Gy; however, this reduction was not statistically significant compared to the control group. Conversely, there was no significant changed in the number of platelets compared to the controls on the 1st and 2nd day of irradiation for other doses. Recovery happens at the same time with a net decrease in the platelet count with an increase in the radiation dose. Red blood cells are not very radiosensitive, so picking them is not reflected cell radiation damage on the scan. It is a suitable candidate for monitoring the effect of radiation for numerous reasons. Firstly, blood is a representative sample for whole-body exposure as it is circulated throughout the body.

Secondly, it is easily accessible and yields cells with intact membranes[15]. Previous studies have been shown significant differences in red blood cell count and hemoglobin in patients[12]. However, the differences in peripheral hematopoietic cell counts were followed exposure to low-dose rate and high dose rate radiation were not statistically significant. The current study was found that the number of red blood cells were increased gradually with increasing IR dose, reaching a maximum at 0.5 Gy, then was decreased until it was reached the minimum at 1 Gy. The maximum RBC count was reached 3 hours after irradiation at a dose of 0.5 Gy The number of red blood cells exponentially is decreased with increasing time. Conversely, were reported a significant decrease ($p<0.001$) in the total RBC count throughout the experiment at all radiation dose levels[16]. Radiation exposure significantly was reduced ($p<0.001$) the number of norm oblasts in the bone marrow, as well as the count of red blood cells, hemoglobin, hematocrit, blood. However, it was increased the myeloid to erythroid ratio. The reported are present the results obtained at radiation doses of 1 and 2 Gy. Throughout the observation period, red blood cell count, hematocrit, and hemoglobin levels were remained within 10% of those recorded from their was radiated case-cum-control donors. Thankfully, the RBC count and hematocrit levels were remained stable after radiation exposure[17].

Limitations of the study

In current three sites of study, it was observed that the personal using CT scan machines were not able to reduce effective doses as well as the equipment used were old and not serviced accordingly and this might have influenced and limited the hematological parameters values and related doses administered to patients .

CONCLUSIONS

Radiation damage can be severely impact hematopoietic cells, even at low exposure levels. It is crucial to be understood the temporal appearance of each symptom with increasing radiation levels to gain insight into the animal model. This study is examined the impact of low-dose ionizing radiation on specific blood components of patients in Congo-Brazzaville. The platelet count is indicated a gradual linear increase in the recovery rate up to 0.4 Gy was followed by a sharp linear increase in the degradation rate up to 0.3 Gy. Both processes occur simultaneously, and an increase in radiation dose leads to a marked decrease in the number by increasing the radiation count of blood components.

Red blood cells are reached their peak count a dose of 0.5 Gy 24 hours post-irradiation. This dose and duration is optimal increasing red blood cell count. The study is concluded that IR is leaded to a significant dose-dependent reduction in blood cell count, which is posed a potential health hazard during radiation exposure. Additional research is recommended to identify other potential health risks of IR that may be impact patients in radiation fields.

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AUTHORS CONTRIBUTIONS

AKIANA F: writing original draft, methodology, investigation. **ATIPO OFGT:** editing, review. **M'KACHER R:** formal analysis, supervision. **DOSSOU J:** methodology, data curation. **MEDENOU D:** writing, review, and editing, data curation. The final manuscript was read and approved by all authors.

DATA AVAILABILITY

The data supporting the findings of this study are not currently available in a public repository but can be made available upon request to the corresponding author.

CONFLICT OF INTEREST

The authors state that they have no competing interests.

REFERENCES

1. Gomes Marin, José Flávio Theranostics in Nuclear Medicine: Emerging and re-emerging integrated imaging and therapies in the era of precision oncology. Radio Graphics 2020; 40(6). *https://doi.org/10.1148/rg.2020200021*
2. Seung Soo Lee and Seong Ho Park. Radiologic evaluation of nonalcoholic fatty liver disease. World J Gastroenterol 2014; 20(23): 7392–7402. *https://doi.org/10.3748/wjg.v20.i23.7392*
3. John M. Boone, William R. Hendee, Michael F. McNitt-Gray. Radiation exposure from CT scans: How to close our knowledge gaps, monitor and safeguard exposure proceedings and recommendations of the radiation dose summit, sponsored by NIBIB February 2011; 265(2):24–25. *https://doi.org/10.1148/radiol.12112201*
4. Seong KM, Seo S, Lee D, *et al*. Is the Linear No-threshold dose-response paradigm still necessary for the assessment of health effects of low dose radiation? Korean Med Sci 31(Supp l1): S10-S23. *https://doi.org/10.3346/jkms.2016.31.S1.S10*
5. Ghorbel I, Sameh M. Disruption of erythrocyte antioxidant defense system, hematological parameters, induction of pro-inflammatory cytokines and DNA damage in liver of co-exposed rats to aluminum and acrylamide. Chemico-Biological Interact 2015; 236:31-40. *https://doi.org/10.1016/j.cbi.2015.04.020*
6. Mykyta Sokolov and Ronald Neumann. Global gene expression alterations as a crucial constituent of human cell response to low doses of ionizing radiation exposure. Int J Mol 2016; 17(1):55. *https://doi.org/10.3390/ijms 17010055*
7. Tucker JD. Low-dose ionizing radiation and chromosome translocations: a review of the major consideration for human biological dosimetry. Mutation Res 2008; 659(3), 211e220. *https://doi.org/10.1016/j.mrrev.2008.04.001*
8. Grande T, Varas F, Bueren JA. Residual damage of lymph hematopoietic repopulating cells after irradiation of mice at different stages of development. Exp Hematol 2000; 28(1), 87e95. *https://doi.org/10.1016/S0301-472X(99)00128-9*
9. Rozgaj R, Kasuba V, Sentija K, Prlic I. Radiation- induced chromosomal aberrations and hematological alterations in hospital workers. Occup Med 1999; 49(6), 353e360. *https://doi.org/10.1093/occmed/49.6.353*
10. Seed TM, Fritz TE, Tolle DV, Jackson WE. Hematopoietic responses under protracted exposures to low daily dose gamma irradiation. Adv Space Res 2002; 30(4), 945e955. *https://doi.org/10.1016/s0273-1177(02)00159-x*
11. Kutkov V, Buglova F, McKenna T. Severe deterministic effects of external exposure and intake of radioactive material: basis for emergency response criteria. J Radiol Protec 2011; 31(2): 237e253. *https://doi.org/10.1088/0952-4746/31/2/003*
12. Elżbieta-Dzięciołowska W, Karaszewska J, Pyśniak K, Smolińska M, Gajewska M. Selected peripheral blood cell parameters in twelve inbred strains of laboratory mice. Animal Science Papers and Reports 2009; 1:69-77.
13. Samimi A, Marzieh HK, Lorestani Z, Shirzad R, Saki N. Oxidative stress in normal hematopoietic stem cells and leukemia. APMIS 2018; 126-4:284-294 *https://doi.org/10.1111/apm.12822*
14. Krigsfeld GS, Sanzari JK, Kennedy AR. The effects of proton radiation on the prothrombin and partial thromboplastin times of irradiated ferrets. Int J Radiation Biol 2012; 88(4): 327e334. *https://doi.org/10.3109/09553002.2012.652727*
15. Shishkina LN, Kushnireva EV, Smotriaeva MA. A new approach to assessment of biological consequences of exposure to low-dose radiation. Radiatsionnaia Biol Radioecologiia 2004; 44(3):289-295. PMID: 15287259
16. Sanzari JK, Cengel KA, Wan XS, Rusek A, Kennedy AR. Acute hematological effects in mice exposed to the expected doses, dose-rates, and energies of solar particle event-like proton radiation. Life Sci Space Res 2014; 2: 86e91. *https://doi.org/10.1016/j.lssr.2014.01.003*
17. Billings PC, Romero-Weaver AL, Kennedy AR. Effect of gender on the radiation sensitivity of murine blood cells. Gravitational and Space Research 2014; 2(1), 25e31. *PMID: 25221782*