Advances in Cancer Science Vol: 2, No 3, 2025, Page: 1-8

The Effect of Radiation Dose on the Number of Leukocytes, Erythrocytes, and Thrombocytes in Cervical Cancer Patients Before and After Radiotherapy

Cicillia Artitin*, Nurmayana

Universitas Baiturrahmah Padang

DOI: https://doi.org/10.47134/acsc.v2i3.9
*Correspondence: Cicillia Artitin
Email: cicilliaartitin@atro.unbrah.ac.id

Received: 30-08-2025
Accepted: 30-09-2025
Published: 30-10-2025

Abstract: This study aims to determine the effect of radiation on the number of leukocytes, erythrocytes, and thrombocytes in cervical cancer patients before and after radiotherapy. This study was conducted at the radiotherapy facility of Arifin Achmad Regional General Hospital in Pekanbaru using a quantitative research method with a retrospective approach and secondary data from the medical records of 18 stage IIB–IIIB cervical cancer patients who underwent total radiotherapy of 50 Gy in 25 fractions. Data analysis was performed using the paired sample t-test and Wilcoxon signed rank test. The results showed a decrease in the mean leukocyte count from $10{,}18\times10^3/\mu L$ to $6{,}81\times10^3/\mu L$, erythrocyte count from $3{,}92\times10^6/\mu L$ to $3{,}55\times10^6/\mu L$, and platelet count from $253{,}72\times10^3/\ \mu L$ to $181{,}39\times10^3/\mu L$. Statistical tests showed a significant difference ($p<0.05$) between before and after radiotherapy. It was concluded that linac radiation had a significant effect on the decrease in the number of leukocytes, erythrocytes, and platelets in cervical cancer patients, so routine blood monitoring during therapy was necessary to prevent hematological complications.

Keywords: Radiation, Radiotherapy, Cervical Cancer, Leukocytes, Erythrocytes, Platelets

Introduction

One of the most deadly types of cancer among women worldwide is cervical cancer (Beddoe, 2019). According to data released by the World Health Organization (WHO) in 2020, cervical cancer ranks fourth as a cause of cancer deaths among women worldwide, with more than 600,000 new cases reported each year. With an incidence rate of 23.4 cases per 100,000 population and a mortality rate of 13.9 per 100,000 population, cervical cancer ranks second in Indonesia after breast cancer. The number of new cervical cancer cases in Riau Province is estimated to reach 800–850 per year. The high incidence rate indicates that cervical cancer remains a major public health problem in Indonesia (Handayani, 2020).

According to Pandey (2017), cervical cancer is cancer that develops in the cervix, or the lower part of the uterus that connects the vagina to the uterus. Oncogenic Human Papilloma Virus (HPV) infection is the main cause of this disease. HPV types 16 and 18, which can cause abnormal changes in cervical epithelial cells, are the main causes (Okunade, 2019). These changes can develop into invasive cancer if not detected and treated immediately. Abnormal bleeding, pelvic pain, and abnormal vaginal discharge are common symptoms (Hwang, 2023). The treatment of cervical cancer, including surgery,

chemotherapy, and radiotherapy, depends on the stage of the disease, the age, and the condition of the patient (Li, 2023).

To prevent cervical cancer, various promotional, preventive, and curative approaches can be used (Sundström & Elfström, 2020). An important step is to raise public awareness about the importance of early detection through Pap smears or HPV tests (Carneiro, 2021). Educating people about risk factors and how HPV is transmitted is also important for changing society towards a healthier lifestyle (Harper & DeMars, 2014). In addition, HPV vaccination is one of the best ways to reduce the risk of cervical cancer. This is especially true for vaccinations given before a person becomes sexually active (Freitas, 2018).

One of the main methods in the treatment of cervical cancer, especially in advanced stages (IIB–IIIB), is radiotherapy. This therapy uses high-dose ionizing radiation, such as high-energy electrons, X-rays, or gamma rays, which damage the DNA of target cells to destroy cancer cells (Umemura, 2024). The main goal of radiotherapy is to stop cancer cells from dividing and multiplying. However, healthy cells around the irradiated area can also be damaged because radiation cannot completely distinguish normal cells from cancer cells (Dhakad, 2022). The hematopoietic system, especially blood cells such as leukocytes, erythrocytes, and thrombocytes, feels the impact (Carter, 2018).

Blood cell formation is aided by bone marrow (Sovani, 2021). During cervical cancer therapy, radiation exposure to the pelvic area can affect bone marrow function, which can lead to a decrease in blood component production (Deng et al., 2024). A decrease in leukocyte count can cause immunosuppression and increase the risk of infection; a decrease in erythrocytes can cause anemia, which reduces tissue oxygenation capacity; and a decrease in platelets can cause hemostasis disorders and bleeding risk (Sharma et al., 2023).

Previous studies have shown that the number of peripheral blood cells can be significantly reduced by radiotherapy. For example, after ten radiation treatments, Prastanti's (2016) study of breast cancer patients found a 16.07% decrease in leukocytes and a 7.33% decrease in erythrocytes. Other studies show that the dose and frequency of radiation fractionation affect the rate of decline in blood cell counts. The radiotherapy dose for cervical cancer is usually 1.8–2 Gy per day with a total of 50 Gy in 25 fractions over 5 weeks, with the aim of providing the best effect on tumor tissue while reducing damage to normal tissue.

Researchers observed at the Arifin Achmad Regional General Hospital Radiotherapy Facility in Pekanbaru from February to April 2025 that 49 cervical cancer patients received LINAC radiotherapy. Based on this phenomenon, there is a strong suspicion that radiation therapy affects the number of leukocytes, erythrocytes, and thrombocytes in cervical cancer patients. However, there is little empirical evidence in the Riau region regarding the extent of the effect of radiation on blood components in cervical cancer patients.

This study aims to determine whether the number of leukocytes, erythrocytes, and thrombocytes in cervical cancer patients before and after radiotherapy differs.

Methodology

The purpose of this quantitative research with a comparative retrospective design is to determine the number of leukocytes, erythrocytes, and thrombocytes in patients with cervical cancer before and after radiation therapy. A retrospective approach was chosen because the data used came from the medical records of patients who had completed a full course of radiotherapy at the Radiotherapy Unit of Arifin Achmad Regional General Hospital in Pekanbaru, Riau Province. This data was collected using Linear Accelerator (LINAC) technology from the entire population of cervical cancer (Ca cervix) patients who underwent external radiation therapy at this facility, totaling 49 patients from February to April. Using purposive sampling, 18 research samples were selected based on specific criteria. The selected patients had to be over 25 years of age, have stage IIB, IIIA, or IIIB cervical cancer, and have undergone a complete series of 25 fractions of therapy with a dose of 50 Gy. The main instrument in this study was a secondary data collection sheet, which was created based on the format of the patient's medical records. All research variables were recorded by the researcher through radiation dose records and laboratory data.

Univariate and bivariate analyses were used to analyze the data. Univariate analysis described the characteristics of the respondents, such as age and cancer stage; bivariate analysis evaluated whether there were differences in the number of leukocytes, erythrocytes, and thrombocytes before and after radiotherapy. In addition, the mean, minimum, maximum, and standard deviation of the number of leukocytes, erythrocytes, and thrombocytes found before and after radiotherapy. The Wilcoxon Signed Rank Test was used to identify abnormal data distribution. The significance level (α) was set at 0.05 with a confidence level of 95%. Decision-making method:

- If $p < 0.05 \rightarrow$ there is a significant difference.
- If $p \geq 0.05 \rightarrow$ there is no significant difference.

Result and Discussion

1. Respondent Characteristics

In this study, 18 patients with cervical cancer who received radiotherapy at the Arifin Achmad Regional General Hospital Radiotherapy Unit in Pekanbaru were taken as subjects. According to medical record data, the characteristics of the respondents are shown in the following table:

Table 1. Distribution of Respondent Characteristics Frequency of Age and Stage of Cervical Cancer Patients.

Age	*f*	%
36 - 45 years old	*4*	22,2
46 - 55 years old	*7*	38,9
56 - 65 years old	*6*	33,3
> 65 years old	*1*	5,6
Total	***18***	**100,0**

Stadium	***f***	**%**
IIB	7	38,9
IIIA	4	22,2
IIIB	7	38,9
Total	**18**	**100,0**

Most respondents were aged between 41 and 50 years (44.4%) and had stage IIB and IIIB cervical cancer (38.9% each). This indicates that cervical cancer patients undergoing radiotherapy are generally of productive age with advanced stages, which is indeed the main indication for radiotherapy as primary or adjuvant therapy.

2. Average Number of Leukocytes, Erythrocytes, and Thrombocytes Before and After Radiotherapy.

The results of the univariate analysis comparison were used to evaluate changes in blood component averages before and after radiation therapy. The comparison results can be seen in the following table:

Table 2. Average Number of Leukocytes, Erythrocytes, and Thrombocytes Before and After Radiotherapy (n = 18).

No	Variable	Treatment	N	Mean	Std. Deviation	Minimum	Maximum
1	Leukocytes	*Pre*	18	10,18	5,68	3,31	21,23
		Post	18	6,81	3,85	2,36	13,59
2	Erythrocytes	*Pre*	18	3,92	0,49	3,13	4,86
		Post	18	3,55	0,49	2,86	4,97
3	Thrombocytes	*Pre*	18	253,72	93,89	104	441
		Post	18	181,39	83,29	63	309

No	Variable	Treatment	N	Normality Test	Benchmark	Description
1	Leukocytes	*Pre*	18	0,033	0,05	Abnormal
		Post	18	0,015	0,05	Abnormal
2	Erythrocytes	*Pre*	18	0,802	0,05	Normal
		Post	18	0,092	0,05	Normal
3	Thrombocytes	*Pre*	18	0,814	0,05	Normal
		Post	18	0,085	0,05	Normal

No	Variable	Treatment	*P value*
1	Leukocytes	*Pre*	0,002
		Post	
2	Erythrocytes	*Pre*	0,001
		Post	
3	Thrombocytes	*Pre*	0,010
		Post	

Based on the results of statistical tests (Paired Sample t-Test and Wilcoxon Signed Rank Test for non-normal data), it was found that all three blood components decreased significantly ($p < 0.05$) after patients underwent radiotherapy, with an average decrease of 33.1% in leukocytes, 9.4% in erythrocytes, and 28.5% in thrombocytes. These decreases indicate the biological effects of radiation on the hematopoietic system of cervical cancer patients.

Discussion

1. The Effect of Radiation on Leukocyte Count

The results showed that after radiotherapy, the leukocyte count decreased significantly from 10.18 × 10^3/μL to 6.81 × 10^3/μL ($p < 0.05$). This indicates that the patient's immune system was directly affected by radiation exposure with a total dose of 50 Gy.

By utilizing direct ionization mechanisms and the formation of free radicals, ionizing radiation damages cell DNA and disrupts cell regeneration. This occurs primarily in tissues that undergo frequent cell division, such as bone marrow (Thangam et al., 2024). Due to their short life cycle and rapid proliferation rate, leukocytes, especially lymphocytes, are the most radiosensitive cells.

Leukopenia, caused by a decrease in leukocytes after radiotherapy, results in a decrease in the patient's resistance to opportunistic infections. This is in line with Qomariah's (2013) study, which found that high-dose radiation can inhibit hematopoietic activity in the bone marrow and reduce the production of immune cells. After ten radiation sessions, leukocytes decreased by 16.07% in breast cancer patients in an additional study by Prastanti (2016).

Therefore, the findings of this study confirm that routine monitoring of leukocytes during radiation therapy is very important to prevent infectious complications.

2. The Effect of Radiation on Erythrocyte Count

The average number of erythrocytes decreased from 3.92 ×10^6/μL to 3.55 ×10^6/μL after radiotherapy ($p = 0.002$). This decrease is associated with the effect of radiation on erythroid progenitor cells in the bone marrow. Although erythrocytes have a relatively long lifespan (±120 days) and consist of cells that are less sensitive to radiation than leukocytes, their formation (erythropoiesis) can still be disrupted if hematopoietic stem cells are continuously exposed to radiation.

Radiation damages microvessels and causes bone marrow tissue hypoxia, inhibiting the synthesis of new erythrocytes. As a result, erythrocyte levels drop and patients are at risk of anemia. This condition is in line with the findings of Edwards (1990) and the WHO (1981), which state that radiation doses below 0.5 Gy can also gradually reduce erythrocyte production over several weeks.

Radiotherapy patients must be monitored regularly for erythrocyte and hemoglobin levels, as a decrease in these levels can cause clinical symptoms such as fatigue, weakness, shortness of breath, and paleness. Thus, patients can receive iron supplementation or transfusions when necessary.

3. The Effect of Radiation on Platelet Count

A significant decrease was also found in platelet count, from 253.72 ×10^3/μL to 181.39 ×10^3/μL ($p = 0.001$). Platelets have a major role in hemostasis and blood clotting. The decrease in platelets due to radiation exposure is caused by damage to megakaryocytes, which are platelet precursor cells located in the bone marrow (Liu et al, 2021).

Within a few days after irradiation, platelets begin to decline because the rate of destruction exceeds the rate of formation, according to Hoffbrand (2016). Thrombocytopenia can occur when platelet counts drop dramatically (below 150,000/μL), which increases the risk of bleeding, especially in cancer patients who are malnourished.

These results are consistent with Qomariah (2013), who stated that a decrease in platelets is the main hematological effect of radiotherapy because DNA ionization interferes with megakaryocytic cell differentiation. Therefore, it is highly recommended to monitor platelets during and after therapy to prevent bleeding complications.

Therefore, it can be concluded that the hematological system of cervical cancer patients is greatly affected by radiation, as indicated by a significant decrease in the number of leukocytes, erythrocytes, and thrombocytes after radiotherapy. This effect demonstrates the systemic impact of the therapy, which must be anticipated through intensive hematological monitoring and integrated clinical preventive measures.

It is hoped that this study will serve as a basis for the development of hematological monitoring guidelines for patients receiving radiotherapy and open up opportunities for further research analyzing the relationship between cumulative radiation dose, irradiation interval, and degree of hematological decline. This study will also include factors such as nutrition, age, and disease status of patients in relation to their level of radiosensitivity.

Conclusion

The results of a study of 18 cervical cancer patients who received radiotherapy at the Radiotherapy Unit of Arifin Achmad Regional General Hospital in Pekanbaru showed that the number of leukocytes, erythrocytes, and thrombocytes changed significantly both before and after radiotherapy. The average leukocyte count decreased from 10.18 × 10^3/μL to 6.81 × 10^3/μL, erythrocytes decreased from 3.92 × 10^6/μL to 3.55 × 10^6/μL, and thrombocytes decreased from 253.72 × 10^3/ μL to 181.39 ×10^3/μL after undergoing a total dose of 50 Gy in 25 radiation fractions. All three test results showed a p value < 0.05, which means that the decrease was statistically significant.

For further research, larger samples should be taken and additional factors such as hemoglobin levels, leukocyte differentiation, duration, and radiotherapy methods used should be considered. In addition, long-term studies can be conducted to evaluate hematological recovery after radiotherapy and to identify factors that influence blood response variations in cervical cancer patients. The results of this study can be used as a basis for developing more comprehensive clinical guidelines for managing the side effects of radiotherapy.

References

Beddoe, A. M. (2019). Elimination of cervical cancer: challenges for developing countries. *Ecancermedicalscience*, *13*, 975. https://doi.org/10.3332/ECANCER.2019.975

Carneiro, M. M. (2021). Cervical cancer elimination: rising up to the challenge. *Women & Health*, *61*(7), 617–618. https://doi.org/10.1080/03630242.2021.1959843

Carter, C. M. (2018). *Alterations in Blood Components*. *12*, 249–293. https://doi.org/10.1016/B978-0-12-801238-3.64251-4

Deng, B., Kong, W., Han, C., Zhou, C., Li, J., Song, D., & Lin, Y. (2024). Study of long-term effects of pelvic radiotherapy on the function of bone marrow in recurrent cervical cancer patients. *International Journal of Medical Sciences*, *21*, 2000–2010. https://doi.org/10.7150/ijms.95900

Dhakad, G. G., Patil, G. D. S. U. V., Nikum, A. C., & Shirsat, S. P. (2022). Review on Radiation Therapy on Cancer. *Research Journal of Pharmacology and Pharmacodynamics*, 4–12. https://doi.org/10.52711/2321-5836.2022.00002

Edwards, A. A. (1990). *Radiation effects on the bone marrow and blood*. Journal of Radiological Protection, 10(3), 163–172. https://doi.org/10.1088/0952-4746/10/3/001

Freitas, A. C. G. S. de, Goncalez, A. J. M., Guimarães, G. C., & Villa, L. L. (2018). *Human papillomavirus vaccination in national immunization programs: impact and perspectives*. *97*(1), 81–97. https://doi.org/10.11606/ISSN.1679-9836.V97I1P81-97

Handayani, S., Dewi, R. M., Wibowo, H. A., Dany, F., Kipuw, N. L., Adelina, R., Adam, K., Yunarto, N., Idaiani, S., & Kristanto, A. Y. (2020). *Cervical Cancer Risk Factor: HPV Infection Among Indonesian Urban Women*. 452–455. https://doi.org/10.2991/AHSR.K.200215.087

Hoffbrand, A. V., & Moss, P. A. H. (2016). *Essential Haematology* (7th ed.). Wiley-Blackwell.

Hwang, E. S., Reading, J. L., Yu, J., Dotto, G. P., Grady, W. M., Czerniak, B., & Serrano, M. (2023). Pre-cancer: From diagnosis to intervention opportunities. *Cancer Cell*, *41 4*(4), 637–640. https://doi.org/10.1016/j.ccell.2023.03.012

International Atomic Energy Agency (IAEA). (2018). *Radiation oncology physics: A handbook for teachers and students*. Vienna: IAEA Publications.

Li, M., Yang, Z., Chen, Z., Jiang, L., & Hong, S.-Y. (2023). *Cervical Cancer Screening and Prevention*. https://doi.org/10.14218/csp.2022.00009

Liu, N., Peng, Y., Peng, Y., Zhong, X., Ma, Z., He, S., Li, Y., Zhang, W., Gong, Z., & Yao, Z. (2021). Effects of exposure to low-dose ionizing radiation on changing platelets: a prospective cohort study. *Environmental Health and Preventive Medicine*, *26*(1), 1–10. https://doi.org/10.1186/S12199-021-00939-Z

Okunade, K. S. (2019). Human papillomavirus and cervical cancer. *Journal of Obstetrics and Gynaecology*, *40*(5), 602–608. https://doi.org/10.1080/01443615.2019.1634030

Pandey, U. (2017). What is Cervical Cancer. 2(5). https://doi.org/10.19080/JGWH.2017.02.555599

Prastanti, D. R. (2016). Pengaruh radioterapi terhadap jumlah leukosit dan eritrosit pada pasien kanker payudara. *Jurnal Sains dan Kesehatan*, 8(2), 45–52.

Qomariah, S. (2013). Pengaruh radiasi terhadap kadar leukosit dan trombosit pada pasien kanker. *Jurnal Kesehatan Budi Mulia*, 5(1), 12–18.

Rizky, H., & Amalia, D. (2020). Tinjauan efek samping hematologis pada pasien radioterapi kanker serviks. *Jurnal Ilmu Kedokteran dan Kesehatan*, 9(3), 134–142.

Sasongko, A., & Rahmawati, N. (2019). Pengaruh dosis radiasi terhadap perubahan hematologi pasien kanker serviks. *Jurnal Radiologi Indonesia*, 11(1), 22–30.

Sharma, A., Tomar, V., Agarwal, N., & Sharma, S. B. (2023). Pathophysiology of pancytopenia: understanding blood cell production and regulation in the bone marrow. *International Journal of Current Pharmaceutical Research*. https://doi.org/10.22159/ijcpr.2023v15i4.3029

Sundström, K., & Elfström, K. M. (2020). Advances in cervical cancer prevention: Efficacy, effectiveness, elimination? *PLOS Medicine*, *17*(1). https://doi.org/10.1371/JOURNAL.PMED.1003035

Syahrani, L., & Puspitasari, R. (2021). Efek radioterapi terhadap sistem hematopoietik pasien kanker serviks di RSUP Dr. Sardjito Yogyakarta. *Jurnal Kesehatan Medik*, 14(2), 110–118.

Thangam, G., Iyyappan, S., & Kumar, S. (2024). *Biological effects of ionizing radiation*. 17–22. https://doi.org/10.58532/v3bkme8p1ch3

World Health Organization (WHO). (1981). *Radiation effects and risks: A report by the Expert Committee on Radiation Biology and Health*. Geneva: World Health Organization.

World Health Organization (WHO). (2020). *Cervical cancer: Estimated incidence, mortality and prevalence worldwide in 2020*. https://www.who.int/news-room/fact-sheets/detail/cervical-cancer