International Journal of Computational and Experimental Science and ENgineering (IJCESEN)

Vol. 9-No.2 (2023) pp. 161-164
http://dergipark.org.tr/en/pub/ijcesen

ISSN: 2149-9144

Research Article

Dose Calibrator Measurements in the Case of Voltage Fluctuations

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Article Info:

DOI: 10.22399/ijcesen.1303582
Received : 27 May 2023
Accepted : 12 June 2023

Keywords

Voltage errors,
radiopharmaceuticals
measurement, voltage

Abstract:

Radiation dose measurements of radiopharmaceuticals and measurements of dose calibrators at different voltages and fluctuations were evaluated. Low and high doses of technetium, iodine and fluorine pharmaceuticals were measured in different voltages. The results showed that only low doses could make small and insignificant differences.

1. Introduction

The field of nuclear medicine covers the process of imaging or treating structures by injecting radioactive materials into the body. Imaging (Diagnosis): Radiation is used to image organs or tissues with the help of a radioactive substance that is injected or inhaled into the body. Radiotherapy (Treatment): Radiotherapy is radiation therapy used to destroy or control cancerous cells [1].

Radiopharmaceuticals are frequently used in treatments or diagnosis processes. The radioactive part of the radiopharmaceutical given to the patient by mouth or intravenously emits radiation such as gamma rays or beta particles[2]. The Nuclear Regulatory Commission (NRC) has made it mandatory to measure the activity to be given to the patient using a dose calibrator before radiopharmaceuticals are administered.

The dose calibrators used for this purpose are used to measure the activity of the radiopharmaceutical to be given to the patient for diagnostic imaging or radionuclide therapy. One can refer to these dose calibrators as well-type ion chambers, which operate based on the principle of ion chambers [3]. A dose calibrator ion chamber includes high voltage source, an amplifier containing electronics, and a display unit.

The ion chambers used in the dose calibrator system are filled with high-pressure Argon gas[4]. When the radiopharmaceutical emits radiation in the ion chamber, it forms ion pairs that generate a potential difference between the two electrodes. As a result, the positively charged ions move toward the cathode and the negatively charged ions move toward the anode, which produces a signal that can be measured [5]. These signals are converted into current by devices connected to the ion chamber. The total current generated in the ion chamber is directly proportional to the amount of radioactive material.

Various problems can arise if the dose calibrator measures incorrectly. There is a risk of giving high doses to the patient because of erroneous measurements. For example, Tc-99m chemically binds to various bioactive substances and produces radiopharmaceuticals used in nuclear medicine imaging[1]. Patients exposed to excessive gamma-ray environmental radiation may suffer various damages. Overexposure to radiation can even bring about genetic effects. These genetic effects occur in mutations in reproductive cells and can be passed on to the next generation[6]. Also shooting with a low

dose will negatively affect the image quality [7]. Therefore, certain conditions are required for the stable operation of dose calibrators. Among these, calibrations such as the exact accuracy test, linearity test, and stability test should be measured.
Apart from calibration tests, the effects of power cuts and **voltage fluctuations** on electronic devices are known. Hospitals, on the other hand, contain devices that need a high voltage source such as MRI (Magnetic Resonance Imaging) and CT (Computer Tomography) devices, and electroshock devices[8].
To prevent these voltage fluctuations in hospitals, special devices designed to provide stable electrical current, and voltage are used. These devices are called regulators or UPS systems (uninterruptible power supply). Regulators provide a stable voltage by reducing voltage fluctuations, while UPS is keeping devices running by providing backup power in intermittent or low-voltage situations. Despite the presence of protective systems and circuits, voltage fluctuations may occur.
Due to these voltage fluctuations, errors may occur in radiation measurements in radiopharmaceutical applications when using dose calibrators. But today, there are high-technology voltage regulation circuits in devices, especially medical devices based on human health.

2. Material and Methods

Capintec - CRC ®-25PET Dose Calibrator [9], Technetium (Tc)-99m, Iodine (I)-131, Fluorine-18 (F-18) radioisotopes and VAR-SAN 0-250V voltage source as you can see in the Figure 1 were used as materials.

Figure 1. *Voltage source*

The CRC-25PET dose calibrator device supply input is connected to the voltage source output. Then, the highly active Iodine-131 radioisotope was transferred to the calibrator well. Voltage values have been adjusted over the voltage source. Initially, values from 10V to 250V were noted. Then the voltage values fluctuated rapidly between 10-250.
This process was also applied to the low-activity Iodine-131 radioisotope, and the values were noted. The same procedure was repeated for Technetium (Tc)-99m and Fluorine-18 radioisotopes, with high and low activity for each.

3. Results and Discussions

The results are in *mCi* units. The voltage values were changed step by step at the power supply, from low to high and high to low.
Figure 2 shows the measurement of high-activity Iodine-131 from 20V to 250V. It has been observed that the difference between low voltage measurement and high voltage measurement is 0.03. With the same measurement method, the low activity Iodine-131 measurement results are shown in Figure 3, it was observed that the difference between 20V and 250V was only 0.003 (Figure 4). In Figure 5, the measurement of the highly active Fluor-18 radioisotope from 20V to 250V is shown. It was observed that the measured value between 50V and 150V increased by 0.06 mCi. In figure 6 the same measurement was made with low-activity

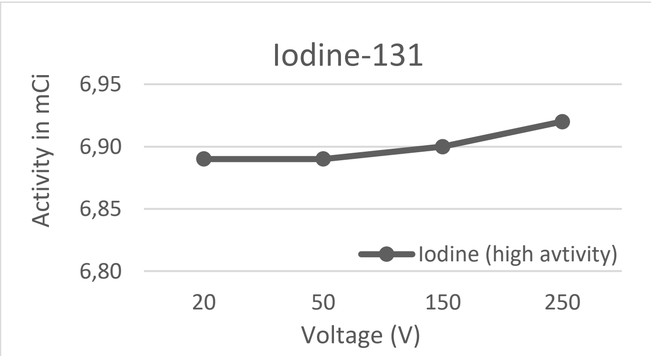

Figure 2. *High-activity Iodine-131 radioisotope*

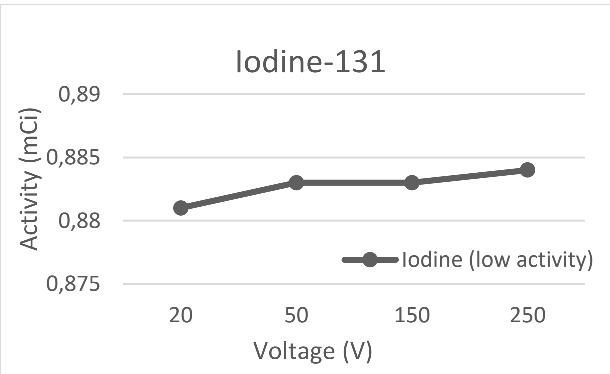

Figure 3. *Low-activity Iodine-131 radioisotope*

Figure 4 *Low activity Iodine-131 at 20 ~ 30V*

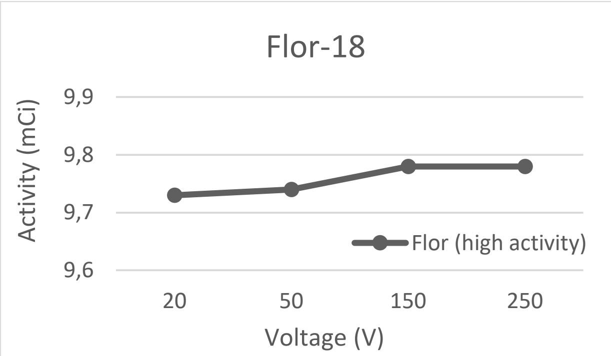

Figure 5. *High activity Flor-18 radioisotope*

Figure 6. *High activity Flor-18 at 20 ~ 30V*

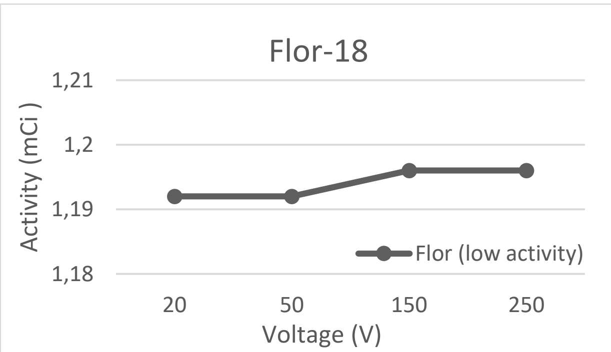

Figure 7. *Low activity Flor-18 radioisotope*

Fluor-18 in Figure-7 and it was observed that the difference in the 20-250V range was only 0.004 mCi. In Figure 8, the calibration device measurements of the high activity Technetium-99 isotope are given depending on the voltage (Figure 9). A deviation of 0.1 mCi was observed, especially between 50V-250V.

Figure 10 shows the measurements of the low-activity Technetium-99 isotope. A difference of 0.01 was noted in Technetium-99 low activity. The results from the measurements are shown in the graphs. We can say that a difference of 0.03 mCi to

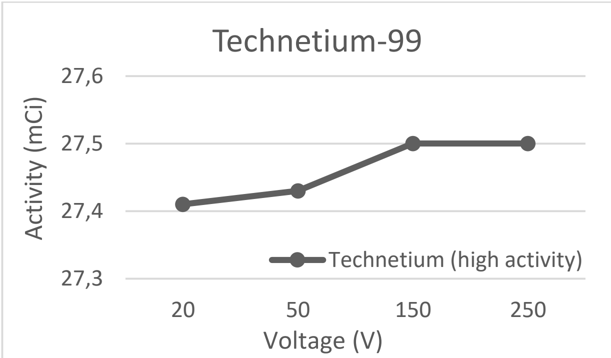

Figure 8.*High activity Technesium-99 radioisotope*

Figure 9. *High activity Technesium-99 at 150V*

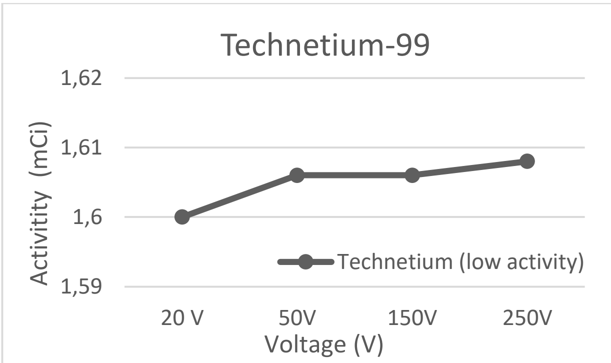

Figure 10. *Low activity Technesium-99 radioisotope*

Figure 11. *Low activity Technesium-99 at 20V*

0.1 mCi was observed from high voltage to low voltage (Figure 11). No change was observed when the voltage was fluctuated. We can say that a higher difference was observed in the technetium-99 high activity measurement. The least difference was observed at the low-activity dose of Iodine. In general, the difference in the higher activities of the isotopes was observed between 0.6 and 0.1. At low activities the difference is much less. There was no significant difference. The reasons will be explained in the next heading.

4. Conclusions

The results show us that nearly 0.1% differences in the radiation dose measurement of radiopharmaceuticals, which may occur from voltage fluctuations, will not have a great impact on human health. Low-activity radioisotopes may be slightly less than the required value at low voltage, and therefore imaging may be slightly impaired.
The reason for this is the strong safety circuits in the device. These safety circuits contain voltage & current protective circuit elements, and transformators. This means that even if the input voltage is 20V or 250V the device amplifies this voltage due to the regulation circuits in it.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** The authors declare that they have nobody or no-company to acknowledge.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

References

[1] Günay, O., Sarıhan, M. , Abamor, E. & Yarar, O. (2019). Environmental Radiation Doses from Patients Undergoing Tc-99m DMSA Cortical Renal Scintigraphy. *International Journal of Computational and Experimental Science and Engineering*, 5(2);86-93.DOI: 10.22399/ijcesen.58926

[2] Zimmerman, B. E., & Cessna, J. T. (2000). Experimental determinations of commercial 'dose calibrator' settings for nuclides used in nuclear medicine. *Applied Radiation and Isotopes* : including data, instrumentation and methods for use in agriculture, industry and medicine, 52(3);615–619. https://doi.org/10.1016/s0969-8043(99)00219-5

[3] Jain AN, Rehman MA. (1981). Quality control of dose calibrators. *Nuklearmedizin* 20:247-50.

[4] Forwood, N., Willowson, K. P., Tapner, M., & Bailey, D. L. (2017). Assessment of the relative contribution of volume and concentration changes in Yttrium-90 labelled resin microspheres on ionization chamber measurements. Australasian physical & engineering sciences in medicine, 40(4);943–948. https://doi.org/10.1007/s13246-017-0601-z

[5] Assan, B. & Addison, Eric & Hasford, Francis & Sosu, Edem. (2012). callibration and effective use of a dose calibrator. *International journal of science and technology*. 2. 395-400.

[6] Javier, Eduardo & Arista Romeu, Eduardo Javier. (2020). Feasibility study for the development of a Dose Calibrator with a well ionization chamber.

[7] Günay, O.,Gündoğdu Ö.,Demir M., Abuqbeita M., Yaşar, Doğan & Aközcan, S.& Kapdan E., Yarar O., (2019). Determination of the Radiation Dose Level in Different Slice Computerized Tomography. *International Journal of Computational and Experimental Science and Engineering.* 5. 119-123. 10.22399/ijcesen.595645.

[8] Guven, D., Kayalica, M. O., & Kayakutlu, G. (2021). Critical Power Demand Scheduling for Hospitals Using Repurposed EV Batteries. *Technology and Economics of Smart Grids and Sustainable Energy*, 6(1), 21. https://doi.org/10.1007/s40866-021-00120-z

[9] Datasheet of device: https://pdf.medicalexpo.com/pdf/capintec/crc-25r-dose-calibrator/70709-191075.html