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Research Article

Assessment of Dose Calibrators Performance in Nuclear Medicine Department in Sudan

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Abstract: This study managed to evaluate the performance of the dose calibrators which work in nuclear medicine departments in Sudanese centers by using four quality control tests accuracy, constancy, linearity and geometry. These four tests was performed for two dose calibrators, Capintec PTW CURIEMENTOR4 (RICK center), and Capintec CRC-25R (Elnilein center) The results of the quality control tests revealed that the parameters that were traced for dose calibrators are within the limits of the International standards (±5%). It is essential to perform daily tests for background activity, constancy, and accuracy. A deviation from normal values of these parameters is the first sign of degradation of the dose calibrator. Regular QC should cover precision, accuracy, linearity, and geometry of instrument, according to IAEA standards, e.g. (IAEA TECDOC-602 and 1599), that will guarantee accuracy of the used patient's radioactive doses and therefore proper practice of nuclear medicine diagnosis. According to descriptive analytical method, it is found that the NM centers generally have acceptable situation in terms of the QC measures for dose calibrator.
Keywords: Dose Calibrator, Nuclear Medicine, Radioactivity.

INTRODUCTION

The radionuclide dose calibrator is used routinely in the clinical nuclear medicine laboratory to make measurements of radiopharmaceutical doses prior to patient administration. Its accuracy and reliability cannot be easily determined by the user unless he understands the instrument's basic structure, method of calibration, and operational pitfalls. A search of the text and research literature indicates that much detailed information is written about ionization chambers perse, with less concern given to dose calibrators [1-7]. Several investigators have reported on the accuracy of dose calibrators used in nuclear medicine, Genna *et al.* [8] used commercial standard sources of ^{99m}TC, ^{57}CO, and ^{137}Cs to check the accuracy of three different doses. They also pointed out that simply purchasing a long-lived standard like cesium or radium to check dose calibrator accuracy is not a fool proof method. We agree with these reports since many factors must be considered in making accurate measurements of each radionuclide.

Feedback from operating experience and lessons learned from accidents or averted accidents can help to identify potential problems and correct deficiencies, and therefore their systematic use as part of the continuous quality improvement process is to be encouraged. The maintenance of management documents and records is an important part of the QA programme, and the management system's documentation needs to be communicated to, understood by, available to and implemented by the appropriate personnel. The organization must establish and maintain procedures to control all documents that form part of its management system. This includes those generated internally and those from external sources, such as regulations, standards, other normative documents, and test and/or calibration methods, as well as drawings, software, specifications, instructions and manuals. Ideally, the person responsible for the overall operation of the QA programme, the quality manager (QM), will identify and provide to the QAC a list of tasks related to QA that need written procedures. The QAC will then establish the person(s) responsible for drafting and signing each procedure and for teaching the procedure to the users, where appropriate. The QAC and the QM will maintain a file with copies of all procedures. All changes are to be reviewed and approved by the group that performed the original review, unless other personnel are specifically designated. The designated personnel must have access to pertinent background information upon which to base their review and approval [10-14]. Acompetent subcontractor is one that, for example, complies with the principles included in this report or a similar accepted standard, as well as with the regulatory

requirements of the country. The laboratory needs to advise the client of the subcontractor arrangement in writing and, where appropriate, gain the approval of the client, preferably in writing [15-16].

Construction and operation

The functional parts of a dose calibrator include a power supply, ionization chamber, current-to-voltage amplifier, voltage gain amplifier, and output display (Fig1). The heart of the dose calibrator is the ionization chamber. The magnitude of current produced in the chamber depends upon the quantity Of radioactivity present. Because of differences in the types of radiations emitted and photon energy and abundance, equal activities of different radionuclides will generate different current flow.

In order to read out the correct activity, the circuit includes a voltage gain amplifier that puts out different Voltages to drive the output display according to the particular radionuclide being measured. In Fig. 1 the range selection switch consists of electrical resistors to provide different activity ranges. An additional plug-in resistor in the isotope calibration box provides an adjustment in the feedback gain of the voltage amplifier so that equal activities of all radionuclides will readout the same value on the display.

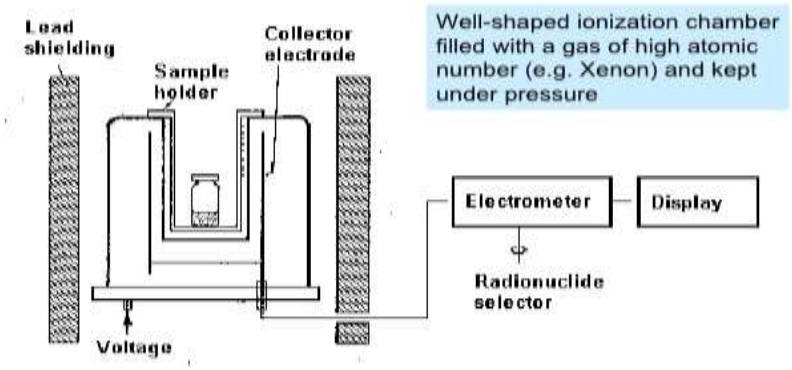

Fig-1: Block diagram of dose calibrator

MATERIAL AND METHOD

Physical inspection

Researcher inspected the instrument housing for evidence of damage. Particularly he examined the surroundings of the ionization chamber for signs of deformation or indentation. He inspected all controls plug-in modules push buttons and switches. He inspected all controls, check that none are missing and examine cables, plugs and socket for evidence of damage. He inspected all accessories such as remote handing devices source holders; check that none are missing or damage. He checked any accompanying sealed radiation sources for external radioactive contamination or leakage. He checked that both operation and service manuals are available. He checked the compatibility of the power supply requirements with available supply and makes any necessary adjustments. He initiated the instrument log-bookmaking an inventory of the instrument and its accessories and recording their condition on and the action taken to correct them. MED Aktivimeter, Isomed, 501 dose calibrator and PTW Curiementor 4 were used for all experimental procedures A linearity check for each instrument was made using ^{99m}Tc-sodium pertechnetate sources contained in 20-ml serum vials and sources ranging in strength from I, 000 to 0.1 mCi were used to check the response of each activity range. Slopes of the decay curves were determined using a log-linear least-squares fit of the data and compared to the currently accepted decay constant for ^{99m}Tc.

An assessment of accuracy of each instrument was made using two sets of standard sources. Technetium 99m contained in 3-ml plastic syringes were made and calibrated using the method of Hare *et al.* [9] and ^{57}CO sources in sealed glass ampules. Each standard was calibrated by measurement in a 4π configuration using a gamma ionization chamberpreviously calibrated with standards certified by the Secondary Standard Dose Lablateries (SSDL).

Each dose calibrator was left on at all times and properly zeroed before measurement. Five independent measurements were made for each source and the results averaged and compared to the calibrated values. Determination of the effect of container configuration on accuracy for measuring radionuclides with widely Differing photon energies was studied in both instruments. Solutions of ^{99m}Tc, were prepared to contain approximately 40 µCi/ml. Each sample was measured in the dose calibrator and its specific concentration calculated as microcuriesj g of solution. The values for each configuration were averaged and compared. Daily and long-term stability of each dose calibrator was studied using a 1-mCi ^{99m}TC source contained in plastic syringes. The source was positioned in a plastic holder designed to fit a fixed geometry for each instrument tested.

RESULTS

The importance of this study is to highlight the importance of the quality assurance program in nuclear

medicine department, In addition to its role to increase diagnosis accuracy and reduce the dose to both patients that is unable to reach by without quality control special in Technetium-99m Generators. The main objective of this study is to assess the performance of the dose calibrators that is being used in nuclear medicine departments. For nuclear medicine, each dose calibrator was being tested for accuracy, constancy, geometry and linearity, where the acceptable level of the tests was determined. T-test was been performed for all score variations in this study. P-value was calculated to show if there is any significant impact of each dose calibrator test.

Table-1: Shows physical inspection test

MANUFACTURE PTW	**PTW**
Model	CURIEMENTOR4
Power	50 TO 60Hz
Volt	(100 TO 230) ±15%
Current	0.05A
Manuals	Available
Radioactive Check source	Available
Condition	Ok
Log-book	Initiated

Table-2: Shows background test

First reading	0.83 mCi
Second Reading	0.92 mCi
Mean	0.875mCi
SD	0.045

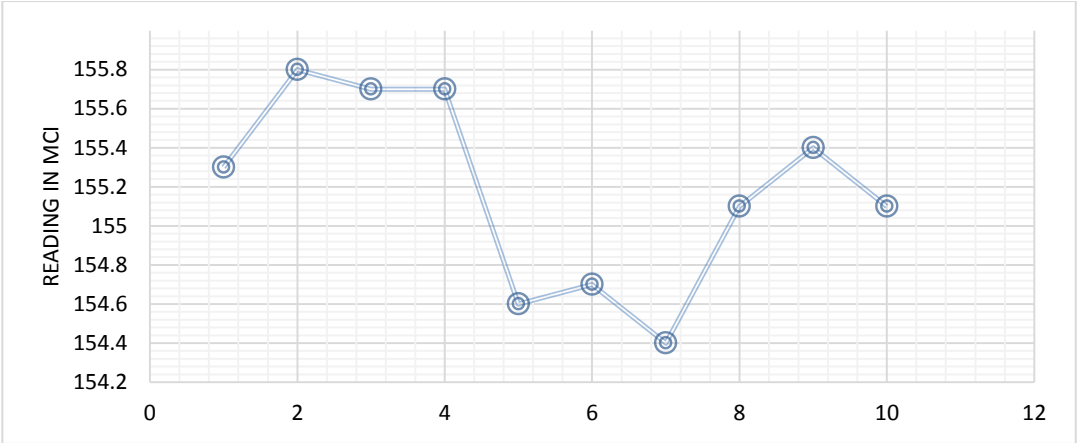

Fig-2: Shows reproducibility test of radionuclide calibrator and the Mean 155.08 and the Standard Deviation 0.579

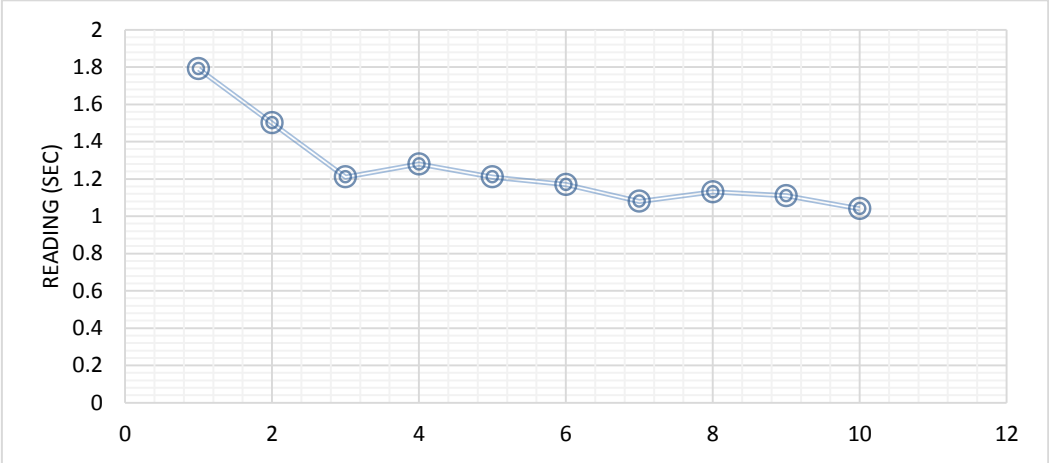

Fig-3: Shows clock accuracy test of radionuclide calibrator and the Mean 1.26 and the Standard Deviation 0.462

Accuracy

The accuracy of a measurement is determined by how close it is to the true value (reference condition).

Accuracy % = (A-C)/A ×100 , Accuracy % = (155.4 – 161.7) / 161.7 ×100= 0.039%

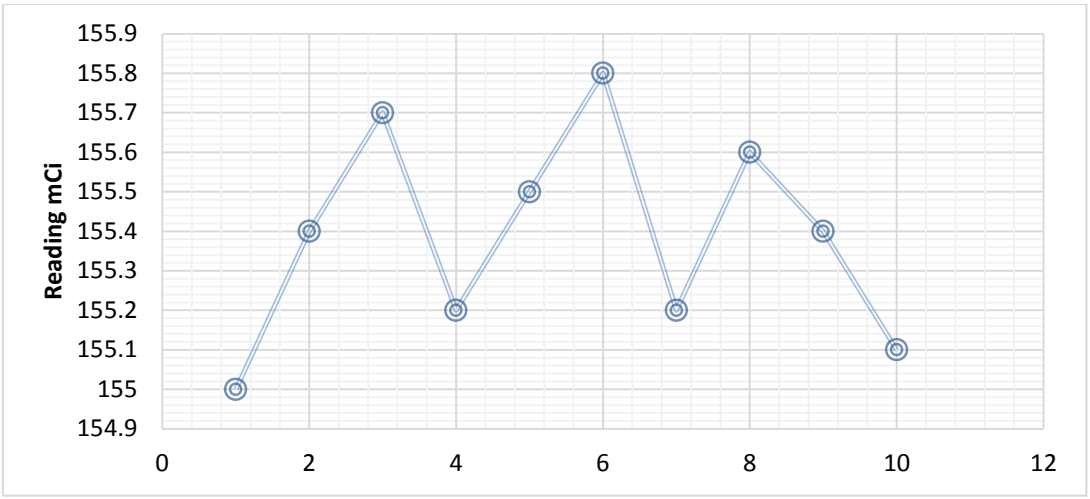

Fig-4: Shows accuracy test of radionuclide calibrator and the Mean 155.4 and the Standard Deviation 0.217

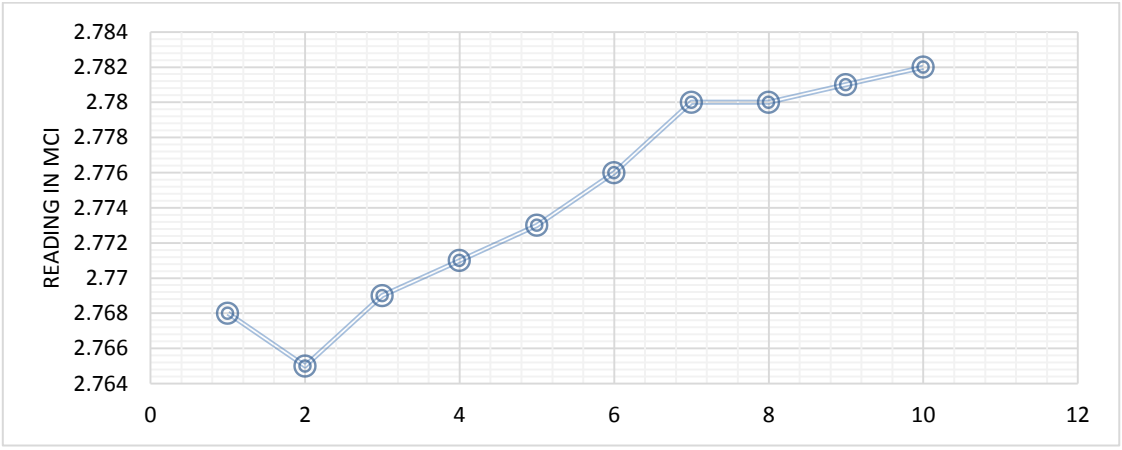

Fig-5: Shows precision test of radionuclide calibrator and the Mean 2.7745 and the Standard Deviation 0.006

Table-3: Shows the mean and standard deviation of errors in Geometry test of dose calibrator measured in Elnielin Center and Radiation Isotopes Center of Khartoum (RICK)

	Elnielin Center	Percentage	RICK	Percentage
Mean	0.171	% 3.6	0.172	% 3.62
Standard Deviation	0.42		0.71	

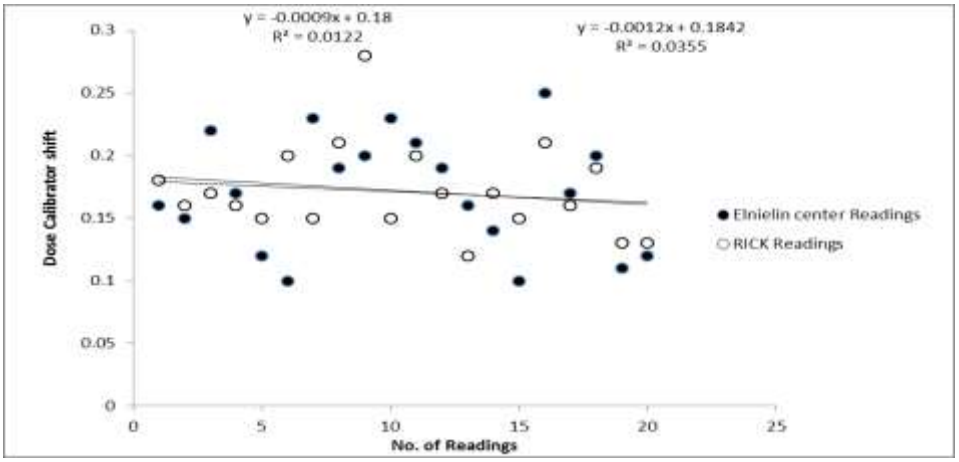

Fig-5: shows the mean and standard deviation of Geometry test of dose calibrator measured in Elnielin Center and Radiation Isotopes Center of Khartoum (RICK)

Independent t-Test on Geometry test of dose calibrator of Elnielin Center and Radiation Isotopes Center of Khartoum (RICK) showed that t = 0.07628 with p = 0.93959 at the 0.05 level, which mean that the two means are NOT significantly different.

DISCUSSION

Concerning the background test, the result of test was good and in normal exposure range (0.785 ±.45 mCi) as showed in table 2. The implementation of radiation protection rules was good in some aspects of the work. No in-house preset standards that were available in printed manuals and also no check listed and permant records. The involvement of technologists directly in management may increase the implementation of the rules concerning quality control of radiopharmaceuticals. The results concerning the reproducibility test of radionuclide calibrator, the day reproducibility of performance of radionuclide calibrator was good with very error (155.08 ± 0.579) as showed in Fig 2. Concerning the training of staff, it is better to increase it by short training courses, especially in area of quality control in nuclear medicine. Concerning clock accuracy, the stabilization of time between two measurements showed no significant different as showed in Fig 3. The results obtained concerning accuracy showed that the dose calibrator has accurate reading and the percentage of error was 0.39% which is accepted. The percentage of accuracy of dose calibrator easily was detected by using accuracy equation. Concerning the precision test, which is a measure of the spread of values obtained from a sequence of measurements. These results showed high precision in dose calibrator. This Geometry test of dose calibrator was done by researcher to show that the calibrator is giving correct readings throughout the entire energy scale that he was likely to encounter. High energy standards (Cs-137 was measured in the dose calibrator using appropriate settings. Standard and measured values are compared. The results were in accepted Fig 5.

CONCLUSION

This is an experimental study deals with evaluation of QC program of dose calibrator. The importance of this study is to highlight the importance of the QA program in NM department, increase diagnosis accuracy and reduce the dose for both patient and technologist. All this cannot be achieved without QC.

For radionuclide dose calibrators, the researcher managed to evaluate the performance of the dose calibrators which work in nuclear medicine departments in Sudanese centers by using four quality control tests accuracy, constancy, linearity and geometry. These four tests was performed for two dose calibrators, Capintec PTW CURIEMENTOR4 (RICK center), and Capintec CRC-25R (Elnilein center) The results of the quality control tests revealed that the parameters that were traced for dose calibrators are within the limits of the International standards (±5%). It is essential to perform daily ests for background activity, constancy, and accuracy.A deviation from normal values of these parameters is the first sign of degradation of the dose calibrator. Regular QC should cover precision, accuracy, linearity, and geometry of instrument, accordingto IAEA standards, e.g. (IAEA TECDOC-602 and 1599), that will guarantee accuracy of the used patient's radioactive doses and herefore proper practice of nuclear medicine diagnosis. According to descriptive analytical method, it is found that the NM centers generally have acceptable situation in terms of the QC measures for dose calibrator.

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