Planar Gamma Camera Uniformity Test Stability Based Power Supply

Sulieman M.S. Zobly and Abdelbagi O. Osman*

Department of Med. physics & instrumentation, University of Gezira, Wad Medani, Sudan

Abstract: Background: Stability of power supply is one of the main problems affecting the performance and continuity of medical equipment in a developing country. Gamma camera is one of medical equipment uses radio isotope for patient imaging.

Objective: There are various parameters degraded image quality in gamma camera. This paper discusses the effect of stability of power supply on image performance.

Methods: To perform this work a total of 125 intrinsic uniformity tests for a gamma camera connected to stable power supply and a total of 125 intrinsic uniformity test for a gamma camera connected to an un-stable power supply were used.

Results: The integral uniformity (central and useful field of view) and differential uniformity (central and useful field of view) were calculated using 99mTc point source.

Conclusion: The result shows that the quality of image degraded in unstable power supply; on the other hand gamma camera connected to the supply via uninterrupted power supply (UPS) was stable and gives highly uniform image in both central and useful field of view.

Keywords: Planar gamma camera, interinsic uniformity, integral uniformity, differential uniformity, power supply.

INTRODUCTION

Nuclear medicine imaging system (planar gamma camera) is one of the most important imaging systems for patient imaging and diagnosis. The purpose of gamma camera imaging system is to obtain a picture of distribution of a radioactive material within the body after it has been administrated to the patient. The most suitable radioisotope for this application is the gamma rays with energy range of 80 to 500 KeV [1]. The gamma camera can be used for either static imaging studies or dynamic imaging studies [1].

To keep the camera performance stable and acquire image of the highest possible quality, the quality control procedures are essential. The quality control (QC) of the planar gamma camera has been described in NEMA standard NU 1-1994 and AAPM report 22 [2,3,4]. The camera performance proposed by NEMA standard describes how manufacturer arrives at the specification of his camera and how to detect the changes in camera performance that may create the image artifacts and alter patient diagnoses. Therefore, number of quality control tests has been designed to ensure optimal camera performance. The most common performance measurement evaluated as the routine gamma camera QC includes intrinsic flood field uniformity test, extrinsic flood field uniformity test, peaking spatial linearity, spatial resolution, energy resolution and center of rotation [2, 5]. The performance test is categorized into two categories; first, the tests those previously have been carried out as reference tests and are repeated according to the manufacturer requirement (weekly, monthly quarterly etc.), second, the daily check which, is carried before starting imaging patients. In this work, we will concentrate on the intrinsic flood field uniformity test (with collimator off), which is used to ensure that the gamma camera is working with high standard of efficiency and reliability.

It’s very important to maintain good flood field uniformity in planar gamma camera. The uniformity test performed in daily basis to verify camera spatial uniformity and measure deviations from perfectly uniform count distribution. It can be measured intrinsically or extrinsically, only intrinsic flood field uniformity is considered in this work. Intrinsic flood field uniformity of a gamma camera is the ability of the camera to produce a uniform image when exposed to homogeneous spatial distribution of gamma rays. The intrinsic uniformity test of the gamma camera system shall be measured for the central field of view (CFOV) and useful field of view (UFOV) for the two parameters, integral uniformity and differential uniformity. The measured values shall meet the manufacturer specification under the normal operation condition [6, 7]. Smallest non uniformity degree in the gamma camera image can cause artifact, which leads to incorrect diagnosis, thus maintaining good uniformity in gamma camera images is very important.

*Address correspondence to this author at the Department of Med. physics & instrumentation, University of Gezira, Wad Medani, Sudan; E-mail: ahmedabdulbagio@yahoo.com
It is very important to avoid performance changes in the gamma camera that might affect the interpretation of clinical studies. The gamma camera uniformity stability affected by different factors such as the volume of radioactive in the syringing, source-camera distance, the number of account, stability of photo multiplier tubs PMTs and the activity of radionuclide are used for imaging. According to the inverse law, the correlation between the source to camera distance and the intrinsic uniformity, intrinsic uniformity increased as distance increased [8, 9]. Unstable power supply is one of the most common reasons for performance changes in gamma camera in countries where the power supply is unstable. Unstable power supply cause drifts in PMTs gain (above / below the correct gain), which leads to fewer counts falling within the energy window, creating a cold area [10].

The most common reason for the damage of electronics and PMTs drift is the sudden loss of power supply. Thus the protection of the gamma camera systems from sudden loss of electricity is essential. In order to protect the machine or any electronic system against the power supply interruptions a battery backup is needed, appropriately named an uninterrupted power supply (UPS). With a UPS it’s possible to run the system on form a long or short time depend on the system consumption of the power and the UPS capacity. This will maintain the stability of the gamma camera.

In this work, we want to study the effect of power supply stability on the planar gamma camera performance. Total of 250 intrinsic uniformity tests were used in this work, both integral and differential uniformity were analyzed. This study helps the user to maintain a good condition of gamma camera.

**INTRINSIC UNIFORMITY**

The uniformity test is one of the most important quality control (QC) tests that can be used for measuring the gamma camera performance on a daily basis before patient studies. The uniformity test performed either extrinsically with collimator on or intrinsically with collimator off. Intrinsic uniformity test is one of the most important tests that is performed on daily basis to ensure the working of the camera in a good condition. Intrinsic uniformity is required before using the gamma for patient studies, so the naked crystal is exposed to a low activity uniform flood source. A non-uniform image must be eliminated before patient imaging to eliminate artifact or false – negative result image [11, 12]. The most common activity sources used for this test are 99mTc and cobalt 57. It’s very important to evaluate the flood image under the same energy used for patient imaging thus 99mTc was used to perform this work. In intrinsic uniformity, both integral and differential uniformity were analyzed over central and useful fields of view [13]. The differential uniformity defined as the maximum change over a five pixel distance in X or Y direction. The integral uniformity defined as maximum pixel count rate change over the indicated field of view. Both integral and differential uniformities were expressed as percentages and calculated as following.

\[
\text{Uniformity(\%)} = \left( \frac{\text{Max} - \text{Min}}{\text{Max} + \text{Min}} \right) \times 100\% \tag{1}
\]

Min and Max are the minimum and maximum pixel counts, respectively. The calculations were done for both useful of view (UFOV) and central field of view (CFOV).

**MATERIAL AND METHODS**

The gamma camera used in this work is the Siemens single head gamma camera upgraded by Mediso medical imaging system installed in 1995 at the institute of nuclear medicine – university of Gezira. The camera equipped with 37 hexagonal photomultiplier tubs (PMTs) and 300 mm diameter 9.5 mm thick NaI (TI) crystal. The main power supply is 220 volt (single phase) and main frequency of 50 Hz.

The point source used was 99mTc, positioned at the center of the detector. The distance between point source and the detector was five field of view of the camera to ensure that the variation between the center and the edge of the crystal is very small. 99mTc can easily produce in the hot lab by eluting it from the long-lived mother isotope 99M, and has a short half-life, that limit excess dose the patient. Above all 99mTc can attached to specially designed pharmaceutical “kits” to form a radiopharmaceutical for specific application and its energy is low enough to be detected with a thin scintillator. Thus 99mTc is the most common isotope used in nuclear medicine application. The point source prepared by using 3 ml syringe, which will be placed at the center of the holder. A holder was used to clamp and center the point source in front of the gamma camera detector. To keep the count rate constant at 30 kcps lead shields were used besides preventing the side scatter radiation to reach the detector.

The source assay carefully, in a calibrated dose calibrator recorded the activity and the calibration time. Appropriate quality control for the dose calibrator was performed on daily basis to ensure that the displayed reading is correct. The activity of the point source used to perform the task at each time was 300 µCi. Fig. 1 showed how the point source positioned in front of the detector of the planar gamma camera.

![Fig. (1). Position of the point source.](image)

**EXPERIMENTAL SETUP**

The photo peak window was centered to 20% according to the manufacture specification when imaging with 99mTc. The energy window is set between 126 KeV and 154 KeV. The collimator was removed and the point source of 99mTc prepared in the hot lab was centered to face the gamma camera detector. The detector moved toward and off the source to archive thirty million counts. The thirty million counts acquired using a matrix size of 256x256x16, total counts of 16 million, a full field detector mask, energy was adjusted to 140 kev, and intrinsic flood corrections.
RESULT

The daily intrinsic uniformity test for the planar camera results in the period from 2004 to 2009 is shown in Figs. 2 - 5. A total of 250 uniformity tests were selected from the stated period randomly, half of the data were before connecting the camera to power stabilizer (January 2004 to September 2005) and half of it were after connecting the camera to power stabilizer (February 2007 to February 2009).

From these results, it was clear that the gamma camera had a uniformity that was within an acceptable range, the integral and differential uniformity for the CFOV after connecting the camera to uninterruptable power supply (UPS) is better than before connecting the camera to UPS. The mean was 2.34 and 1.67 against 2.82 and 1.88, the STD was 0.32 and 0.15 against 0.95 and 0.45 for integral and differential uniformity sequentially, while the integral and differential uniformity for the UFOV after connecting the camera to UPS, was 2.64 and 1.77 as mean against 3.71 and 2.77, the STD was 0.35 and 0.17 against 1.80 and 1.28 for integral and differential uniformity sequentially.

The integral uniformity for the CFOV lied between 4.0% and 1.9% (when camera was connected to UPS) against the acceptance test value of 3.3% at installing time, while the differential of the UFOV had values between 2.5% and 1.4% against 2.7% for the installation acceptance test.

DISCUSSION

Gamma camera uniformity test is one of the most sensitive parameters to change system performance [7]. One of the things that affect image uniformity is the PMT and detector’s performance. Hence, intrinsic uniformity is probably the most important quality control (Q.C.) test that can be performed on a gamma camera system on a daily basis. One of the effects of PMT “drift” is the appearance of hot or cold spots in the flood image. Thus the uniformity of the image in the gamma camera depends on the stability of the PMTs, detectors and the electronic boards used in the machine. The stability of PMTs and the electronics change with the time, this also can cause change in gamma camera uniformity. The camera considered to have a good uniformity image when the uniformity tests of the camera ≤ 2% [7]. Deterioration in intrinsic flood field uniformity in the gamma
camera can cause by variation in PMTs and their associated electronics [14]. The stability and performance of the detector, PMTs and electronic circuits in the gamma camera are highly dependent on the electric power supply connected to the gamma camera (input power supply). Thus, most of the manufacturers recommended that the camera must be connected to the power supply all the time for the detector stability; also they recommended the uniformity test performed after six hours or more, when the power supply restored after a power failure because the detector needs time to be stable [14].

From the results presented in Fig. 2 to Fig. 5 above, all uniformity tests performed after using the UPS had values that fall within acceptable range, on the other the uniformity tests results before using UPS contained very high values. From Fig. 2, the integral uniformity (UFOV) percentages after connecting the camera to UPS were plotted against the integral uniformity before UPS connection, which showed very small percent which indicated a good result, while the integral uniformity percentages before connecting the camera to UPS were showed relatively very high percent which indicated poor result. From Fig. 3, the differential uniformity (UFOV) percentages after connecting the camera to UPS were plotted against the differential uniformity before UPS connection, which shows that, a very low differential values after using UPS.

From Fig. 4, the integral uniformity (CFOV) percentages after connecting the camera to UPS were plotted against the integral uniformity before UPS connection, which showed very small percent which indicated a good result, while the integral uniformity percentages before connecting the camera to UPS were showed relatively very high percent which indicated poor result. From Fig. 5, the differential uniformity (CFOV) percentages after connecting the camera to UPS were plotted against the differential uniformity before UPS connection, which shows that, a very low differential values after using UPS.

In general, the uniformity tests results after moving the gamma camera and connected to the UPS are better than before.

CONCLUSION

The uniformity tests performed by the camera before connecting UPS was high, which indicates instability of camera performance that required long time to return the camera back to stable condition.

When using the UPS, the camera performance was stable and gave acceptable uniformity values. This indicates that, the camera should be connected to stable power supply all the time, and should be in routine work regularly. Generally, the performance of the camera will be high if always connected to the stable power supply. The UPS is very important in nuclear medicine department, especially in the imaging systems in the developing country to overcome the loss of power during the period of main supply interrupted.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES


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