

Quality Control of Gamma Camera with SPECT Systems

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Abstract

Quality control of Gamma Camera with SPECT System is highly valuable for assurance performance characteristic. We report the performance characteristic of gamma camera by intrinsic calibration and verification measurement. The study has been done using the data from Siemens Symbia S Series gamma camera by using a point source ^{99m}Tc at the Institute of Nuclear Medicine & Allied Sciences (INMAS), Khulna, Bangladesh. From intrinsic calibration and verification flood series, the integral uniformity for the central field of view (CFOV) has been found in between 4.01% and 2.88% and for the useful field of view (UFOV) has been in between 4.77% and 4.30%. The differential uniformity for the CFOV has been in between 1.53% and 2.04% and for the UFOV has been in between 2.32% and 2.77%. According to Operating Instruction Symbia System S Series manual, uniformity can compensate for values exceeding 10%, however while integral uniformity exceed 7%, have to contract Siemens customer service representative. In conclusion, these results show that the intrinsic uniformity of the gamma camera under this condition is within an acceptable range; thus the gamma camera working in INMAS is performed well.

Keywords

Gamma Camera, SPECT, Quality Control, Intrinsic Uniformity

1. Introduction

Gamma Camera is a major imaging device used in Nuclear Medicine. It is a diagnostic instrument which is used to image the radiation from a radiotracer inserted into patient's body. It scans the radiation area of the radiotracer and produces an image. The main purpose of Gamma Camera is to identify cancer tis-

sues, proper abnormalities and other internal problems inside a patient’s body. In the 1950s, Hal Anger conducted studies on medical imaging and from 1952 to 1958; he gradually developed the scintillation camera, also known as the Anger camera [1]. After developing gamma camera we get multiple gamma camera which generate a three dimensional image. Single photon emission computed tomography (SPECT) and positron emission tomography (PET) obeys this technology. In SPECT system, we get a scintillation camera mounted around the patient’s body and it is connected to a proper computer system. The basic principle of a SPECT system dependent on the rotating camera concept is that a series of planar images are collected while the camera is rotated through either 180° or 360° around the patient [2]. The main purpose of Gamma camera with SPECT system is to scan brain heart, respiratory, liver and kidney. It is used for clinical studies producing better image and making diagnosis easier. The SPECT system is more sensitive than an ordinary gamma camera, so we should take a special technical support. The SPECT gamma camera is much more complex diagnostic instrument and it is more expensive to purchase and maintain.

The gamma camera is made up of many parts, each part performs as a specific function in converting gamma rays into light images and finally we get appropriate viewing image. The basic components of gamma camera are collimator, sodium iodide (NaI) crystal, photomultiplier tubes (PMT) and position logic circuit. **Figure 1** illustrates the basic principles and components of the gamma camera.

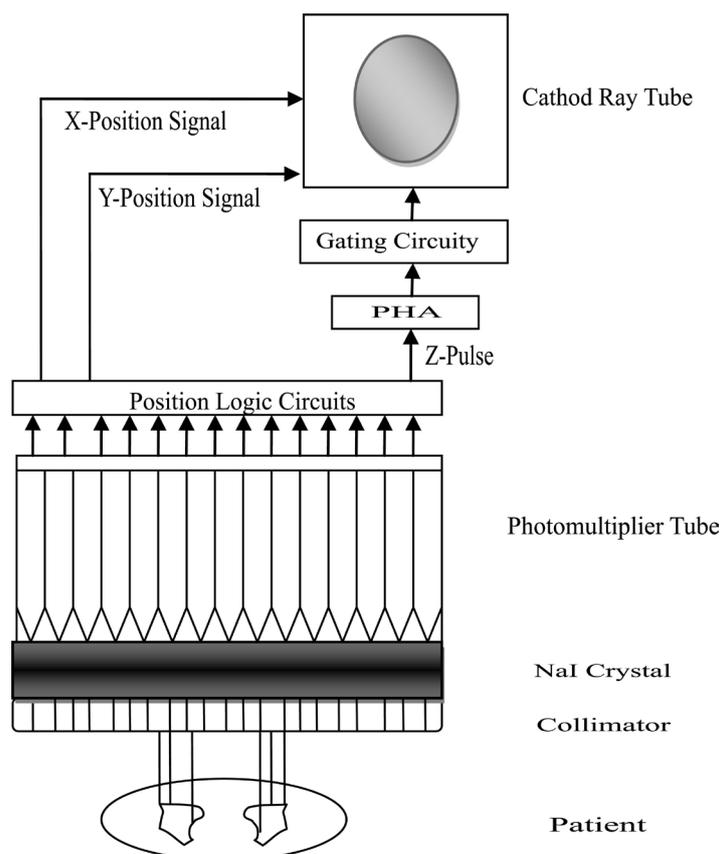


Figure 1. Basic principles and components of the gamma camera.

The radiotracer emits gamma rays as it decays and the gamma rays travel towards the detector. The gamma rays have to pass through the collimators which ensure that it travels at a specified angle with respect to the detector crystal. The sodium iodide crystal converts the gamma rays into light. The photomultiplier tube converts the light into electrical signals. Finally these electrical signals are used to determine the position and the energy signals of the gamma rays.

A study of gamma camera intrinsic uniformity with SPECT system is presented as an index of quality assurance. Uniformity measurement is one of the parts of quality control of Gamma Camera. The uniformity measurements may be intrinsic or extrinsic. The intrinsic measurements are carried out without collimator and the extrinsic measurements are carried out with collimator [3]. It is one of the primary tests performed on the gamma cameras [4]. It is also one of the indices used to measure the performance of a gamma camera. Intrinsic flood uniformity test is a part of the quality assurance programme of a nuclear medicine department that ensures high standards of efficiency and reliability in the use of a gamma camera [5]. We thus avoid changes in the performance of a gamma camera system that might affect the interpretation of clinical studies [6]. Two uniformity parameters are computed for intrinsic uniformity measurement. These are integral uniformity and differential uniformity. Integral uniformity is a global parameter measuring uniformity over an extended area of the detector, expressed as follows [7]:

$$\text{Integral uniformity} = \frac{(\text{Max} - \text{Min})}{(\text{Max} + \text{Min})} \times 100\%$$

Where Max is the maximum count and Min is the minimum count found in any pixel within the specified area. Differential uniformity is a regional parameter that measures contrast over a small neighborhood. This measurement is performed using all 5×1 —pixel areas in both the X and Y directions, expressed as follows:

$$\text{Differential uniformity} = \frac{\text{Largest deviation} (\text{Max} - \text{Min})}{(\text{Max} + \text{Min})} \times 100\%$$

The main aim of this study is to assure the performance characteristic of Gamma Camera by intrinsic calibration quality control studies (intrinsic calibration and verification measurement). This study was carried out on March 19, 2014.

2. Materials and Methods

From this study the following procedures were used for Siemens Symbia S Series Gamma Camera with double head (Siemens Medical Solutions U.S.A, Inc.). The Gamma Camera has two detectors which we indicated as Detector 1 and Detector 2. The specifications of the Gamma Camera are—thickness of the NaI crystal 9.5 or 15.9 mm, size of the crystal 59.1×44.5 cm (diagonal size 73.9 cm), number of photo multiplier tube 59, the dimensions of the detector field of view (FOV) is 53.3×38.7 cm (diagonal FOV is 65.9 cm). ^{99m}Tc gamma point source

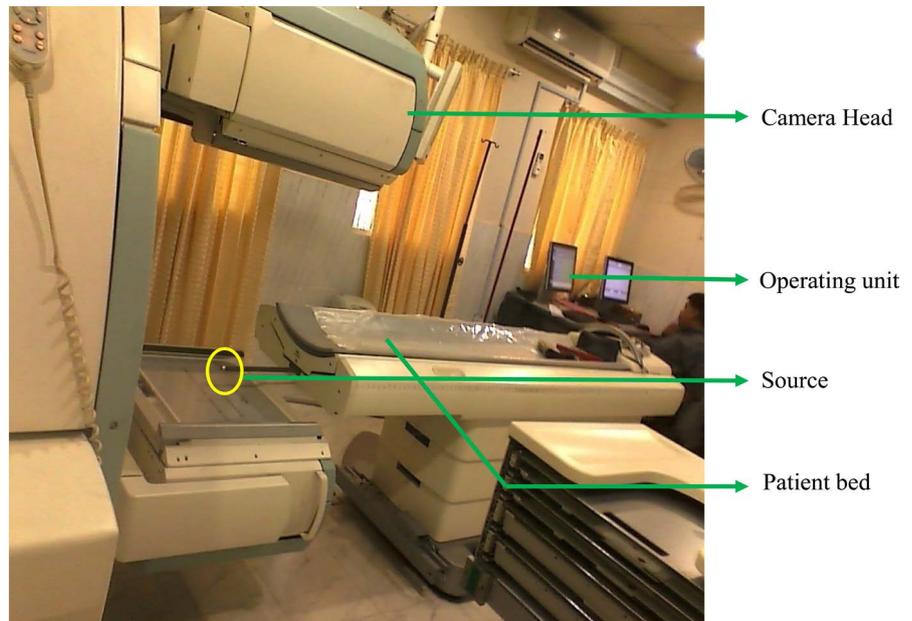


Figure 2. A partial view of gamma camera for this test.

activity, the number of acquired counts for the flood image, source-to-detector distance, image matrix size and source volume were evaluated to determine the ideal procedure for the quality control of Gamma Camera. **Figure 2** shows a partial view of Gamma Camera for this test.

The collimator was removed from the camera. The integrated source holder was extended from its storage position on the rear bed and pulled until the source holder was approximately centered. The prepared point source in the vial was inserted, with the capped end of the vial, into the source holder. The activity of the point source was $28 \mu\text{Ci}$ and its volume was 0.1 ml. The distance from point source-to-detector was at least 4 times the field of view (FOV) diameter from the detector. Camera surface and the room were cleaned to insure there was no contamination and verified that the background count rate display on the PPM (Patient Positioning Monitor) was less than 0.4 kcts/sec. In performing intrinsic calibration and verification measurement checked that the count rate displayed on the PPM was between 15 kcts/sec and 50 kcts/sec to insure that the source strength was appropriate. In performing intrinsic calibration measurement the system acquired an uncorrected 200 million count flood for both detectors simultaneously and in performing intrinsic verification measurement the system acquired a 10 million count corrected flood on both detectors simultaneously. For both intrinsic calibration and verification measurement the image matrix size was 1024×1024 and a zoom factor was 1.00 and its adjusted energy window was 15%. We initially followed the manufacture's instruction for the quality control test. All the working function of intrinsic calibration and verification measurement of the Gamma Camera (both differential & integral uniformity) were performed using Singo and *e.soft* software provided by the manufacture. The integral and differential value was determined automatically by this SPECT Gamma Camera software.

3. Results and Discussion

System uniformity is the most sensitive parameter to changes in system performance [8]. One of the things that affect image uniformity is the PMT (photo-multiplier tube) 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. This in a way shows that the uniformity of the images is dependent on the stability of the PMT and sometimes on the associated analogue electronic components. It is also dependent on the stability of the detector. When the uniformity of the camera is $\leq 2\%$ the camera is considered to have a good uniformity [8].

In the present work the intrinsic uniformity of gamma camera installed at INMAS, Khulna, Bangladesh, was studied as an index of performance test. For this purpose intrinsic calibration flood series and verification measurement flood series were done which is shown in **Figure 3** and **Figure 4** respectively. Differential and integral uniformities for useful field of view (UFOV) and central field of view (CFOV) of Detector-1 and Detector-2 for intrinsic calibration and verification measurement were observed and the results are summarized in **Table 1** and **Table 2** respectively. The integral uniformity for the central field of view (CFOV) was found to be between 4.01% and 2.88% while the integral uniformity for the useful field of view (UFOV) was between 4.77% and 4.30%. The differential uniformity for the CFOV was between 1.53% and 2.04% while that of the UFOV was between 2.32% and 2.77%. The integral uniformity has typical values of 2% to 5% [9]. For differential uniformity in most cases, a value of less than 3% is obtained after uniformity correction [10]. When the value for

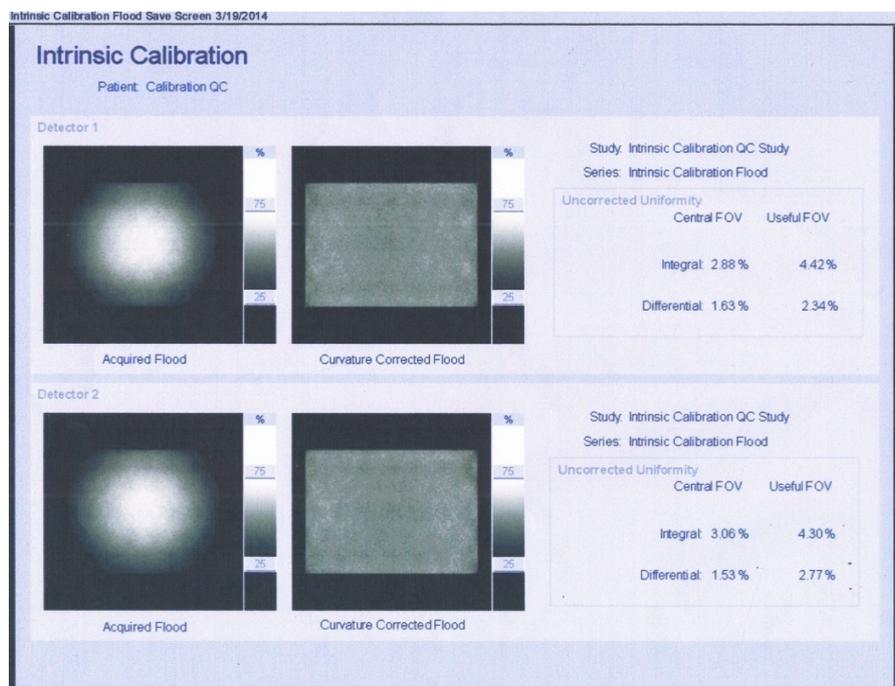


Figure 3. Intrinsic calibration flood series.

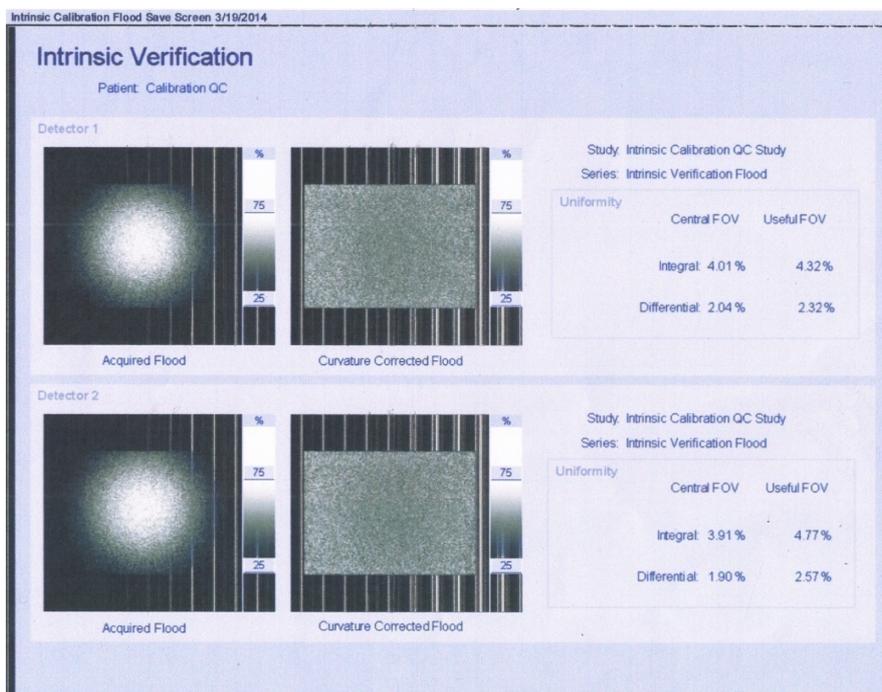


Figure 4. Intrinsic verification flood series.

Table 1. Intrinsic calibration measurement.

Detector		Intrinsic Uniformity (%)	
		UFOV	CFOV
Detector-1	Differential Uniformity	2.34	1.63
	Integral Uniformity	4.42	2.88
Detector-2	Differential Uniformity	2.77	1.53
	Integral Uniformity	4.30	3.06

Table 2. Intrinsic verification measurement.

Detector		Intrinsic Uniformity (%)	
		UFOV	CFOV
Detector-1	Differential Uniformity	2.32	2.04
	Integral Uniformity	4.32	4.01
Detector-2	Differential Uniformity	2.57	1.09
	Integral Uniformity	4.77	3.91

differential uniformity exceeds 3%, maintenance service should be carried out on the gamma camera [11]. From these results, it was clear that the gamma camera had flood uniformity that was within an acceptable range.

For major uniformity defects consistent with crystal damage or detector malfunction, the intrinsic calibration flood should be reviewed. Mild variations in uniformity may occur with a properly functioning detector and will be removed by the uniformity correction. Uniformity values may be used as a guide to dis-

tinguish between acceptable and unacceptable levels of uniformity. The intrinsic calibration concludes with a corrected verification flood to assess the corrected performance of the system immediately following calibration and the results of this flood may be used as a baseline for comparison of subsequent daily intrinsic verification floods. Provided the intrinsic calibration flood was performed correctly, the corrected intrinsic verification flood should appear visually uniform with the uniformity numbers determined by the statistics of the low count flood and the results of this flood may be used as a baseline for comparison of subsequent daily intrinsic verification floods [12].

4. Conclusion

Uniformity measurement is one of the parts of performance test of gamma camera. In this work the intrinsic uniformity of gamma camera with SPECT system was studied by intrinsic calibration and verification measurement flood series technique. From this study, we observed that differential and integral uniformities under this condition do not exceed the Operating Instruction Symbia System S Series Manual value (10% for DU and 3% for IU). Thus it may be concluded that the gamma camera working in INMAS at Khulna in Bangladesh is performed well.

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