ORIGINAL ARTICLE

PERTINENT QC TESTS FOR GAMMA CAMERA PERFORMANCE IN A BUSY NUCLEAR MEDICINE DEPARTMENT: AN AUDIT

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ABSTRACT

BACKGROUND: In nuclear medicine imaging comprehensive quality controls procedures are used to ensure the accuracy and reproducibility gamma camera. However, these are time consuming. In practice, however, less time-consuming and less rigorous procedures often suffice for day-to-day QC. We are presenting an audit of QC of dual head gamma camera of a Nuclear medicine department of a tertiary care hospital in Karachi. **MATERIAL AND METHOD:** This audit was performed at Nuclear medicine department of Liaquat national hospital (LNH) Karachi, Pakistan from 1st October 2016 till 31st Dec 2015. We perform background count, energy peaking, % energy resolution (full width half maximum; FWHM), % central and uniform field of view (% CFOV and % UFOV), total counts and count rate. **RESULTS:** Mean background counts (Kcnts) detected by Detector-1 was 0.24 and for Detector-2 was 0.22 which were well within NEMA benchmark but values of detectors were significantly different. Mean % energy resolution (%FWHM) for Detector-1 was 09.89 and for Detector-2 was 10.364 (within NEMA standards) but significantly difference between 02 detectors. Mean count rate (Kcnts/s) detected by Detector-1 was 14.27 and for Detector-2 was 15.91 (well within NEMA benchmark) but significant difference between counts rate of 02 detectors was found. **CONCLUSION:** We conclude that less time consuming and convenient procedures like background count, energy resolution and mean count rate measurement are sensitive tests for daily QC of a busy nuclear medicine department.

Keywords: Gamma camera; Quality control; uniformity; energy resolution; Electronic drift

Introduction

In nuclear medicine department, the primary purpose of a quality control (QC) program is to verify the accurate distribution of radiopharmaceuticals of in acquired images. Basic Safety Standards issued by International Atomic Energy Agency (IAEA) narrates that all equipment used in nuclear medicine for examination or treatment purposes must be subject to internal quality control.[1] QC tests have an important, sensitive role in monitoring changes in performance so that service can be scheduled and performed before the need becomes critical and requires cancellation of patient studies.[2] The performance parameters most commonly evaluated as part of a routine γ-camera QC program include uniformity, spatial resolution, spatial linearity and energy resolution and peaking.[3]

We are presenting an audit of QC of dual head gamma camera of a Nuclear medicine department of a tertiary care hospital in Karachi.

Material and Method

This audit was performed at Nuclear medicine department of Liaquat national hospital (LNH) Karachi,

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Pakistan from 1st October 2015 till 31st Dec 2015. We perform background count, energy peaking, % energy resolution (full width half maximum; FWHM), % central and uniform field of view (% CFOV and % UFOV), total counts and count rate. Prior to starting QC test, we first physically check whether the gamma camera is in home position, detector sensors are working or not, table fully out of detectors or not. These QC tests are performed early in the morning before the patient procedures to assure that the gamma camera is working smoothly fulfilling all quality assessments tests with optimum image quality and resolution necessary for diagnosis.

A. **Background Count:** It is performed to check whether there is any unnecessary radiation in imaging suite that could interfere with the system performance. This test was performed in Home mode (H-mode) with low energy high resolution collimators (LEHR) mounted to both detectors and verified that both detectors are selected by computer and acquisition was started to acquire background counts for one (01) minute. The protocol is set for all type of radioisotope that could be present in background within the imaging suite (Technetium-99m, Cobalt-57, Iodine-131).After completion of acquisition, results were displayed on the screen, showing any presence or absence of any radioactive substance in the room. The acceptable results in H-mode with collimators for background should be less than 0.6 Kcnts/sec as per vendor specifications.

B. **Image Quality Test:** For this we used a Co-57 flood source having 10 mCistrength (Ref. Activity 10 mCi and Ref. Date 1st July 2015). The LEHR collimators were in H-mode (H QC D-1&D-2). The flood source was placed in center, equidistance from both detectors (D1 at zero degree and D2 at 180 degree) and table was fully out of gantry so that they could measure same reading. It was ensured that the count rate detected by each detector should always be less than 45 Kcnts/ detector as per vendor specification. Acquisition terminated as each detector detected atleast a count rate of 4000 Kcnts/Detector while the upper limit should be always less than 400000 Kcnts/Detector. The peak position for Co-57 should be equal to 122 ± 3 KeV, energy resolution (FWHM) < (12%), CFOV integral uniformity < (5%), UFOV < (5.5%). If these values come within these targets, the test pass and in case of failure then periodical NM calibration and QC was supposed to be performed for correction as per vendor's recommendation.

Results

Mean background counts (Kcnts) detected by Detector-1 was 0.24 and for Detector-2 was 0.22. These are well within NEMA benchmark. However, there was statistically significant difference between the background counts detected by 02 detectors (Tab. 1). (Fig. 1) shows Blond Altman's comparative analysis of mean background counts of two detectors which shows minimal scatter around mean (within 2 SD) and these values are well within upper and lower NEMA limits. Mean energy peak (KeV) detected by Detector-1 was 123.1 and for Detector-2 was 122.4. These values are well within NEMA benchmark. However, there was statistically significant difference between the energy peaks detected by 02 detectors (Tab. 1). (Fig. 2) shows Blond Altman's comparative

QC Variables	Dectector 1	Dectector 2	t-test	P value	NEMA limits
Background (Kcnts)	0.24 ±	0.22 ±	-12.25	<0.0001*	≤ 0.6
Mean ± 2SD	0.01	0.01			
Energy Peak (KeV)	123.10 ±	122.41 ±	-6.17	<0.0001*	123 ± 3
Mean ± 2SD	0.76	0.60			(120-126)
%Energy FWHM	9.89 ±	10.36 ±	8.42	<0.0001*	≤ 12
Mean ± 2SD	0.26	0.42			
%CFOV	2.90 ±	3.16 ±	3.033	0.003	≤ 5
Mean ± 2SD	0.53	0.52			
%UFOV	3.48 ±	3.74 ±	2.19	0.03	≤ 5.5
Mean ± 2SD	0.72	0.73			
Count rate	14.27 ±	15.91 ±	5.35	<0.0001*	≥ 1- ≤ 45
(Kcnt/s)	1.94	1.81			

*p<0.0001
QC =Quality Control
SD =Standard Deviation
NEMA =National Electrical Manufacturers Association
Kcnts =Kilo counts
FWHM =Full Width Half Maximum
CFOV =Central Field of View
UFOV =Uniform Field of View

Table 1: Gamma Camera quality control data from October till December 2015

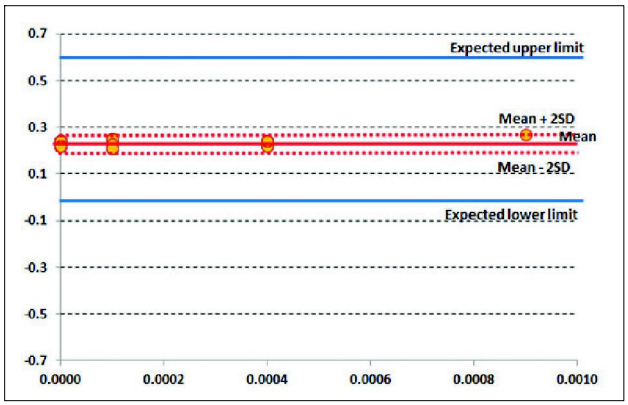

Figure 1: Blond Altman's comparative analysis for measured values and expected range for background (Kilo counts/second) in both detectors.

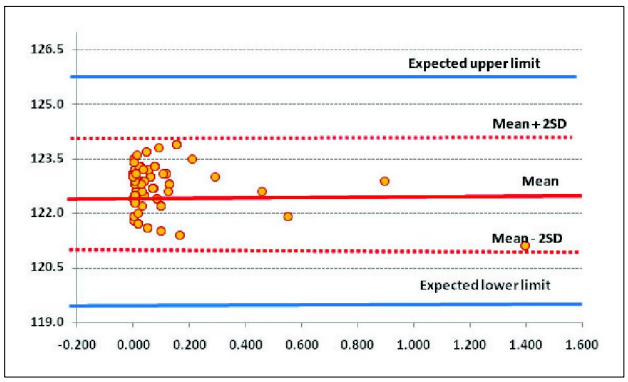

Figure 2: Blond Altman's comparative analysis for measured values and expected range for energy peak in both detectors.

analysis of mean background counts of two detectors which shows minimal scatter around mean (within 2 SD) and these values are well within upper and lower NEMA limits.

Mean % energy resolution (%FWHM) for Detector-1 was 09.89 and for Detector-2 was 10.364. These values are well within NEMA benchmark. However, there was statistically significant difference between the energy resolutions of 02 detectors (Tab. 1). (Fig. 3) shows Blond Altman's comparative analysis of energy resolution (%FWHM) of two detectors which shows minimal scatter around mean (within 2 SD) and these values are closer to the NEMA upper limit.

Mean % CFOV and % UFOV of Detector-1 were 2.90 and 3.48 and for Detector-2 were 3.16 and 3.74 respectively (Tab. 1). These are well within NEMA benchmark. Although there is difference in calculated values but these are statistically non-significant (p value > 0.5). (Fig. 4 & 5) show Blond Altman's comparative analyses of mean CFOV and UFOV of 02

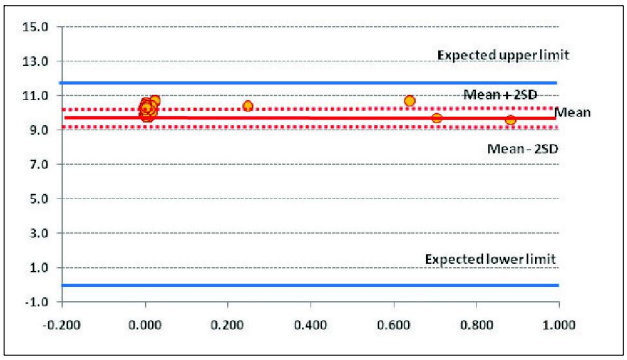

Figure 3: Blond Altman's comparative analysis for measured values and expected range for % energy resolution in FWHM in both detectors.

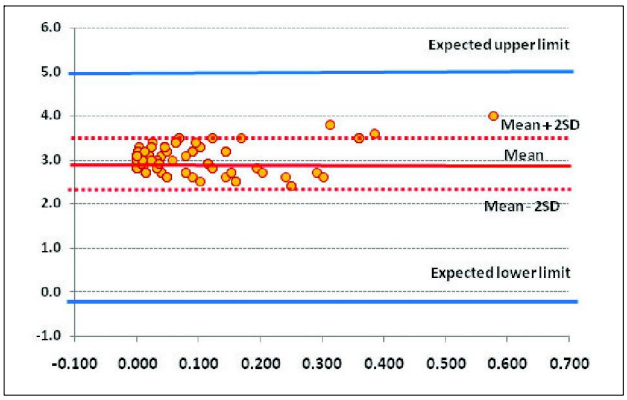

Figure 4: Blond Altman's comparative analysis for measured values and expected range for % CFOV in both detectors.

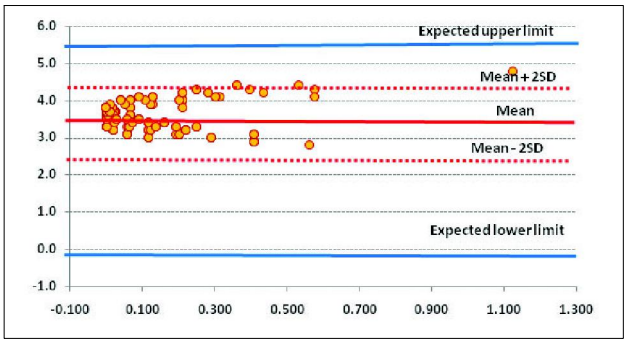

Figure 5: Blond Altman's comparative analysis for measured values and expected range for % UFOV in both detectors.

detectors which shows minimal scatter around mean (within 2 SD) and these values are well within NEMA standards.

Mean count rate (Kcnts/s) detected by Detector-1 was 14.27 and for Detector-2 was 15.91. These are well within NEMA benchmark. However, there was statistically significant difference between the counts rate detected by 02 detectors (Table 1). (Fig. 6) shows

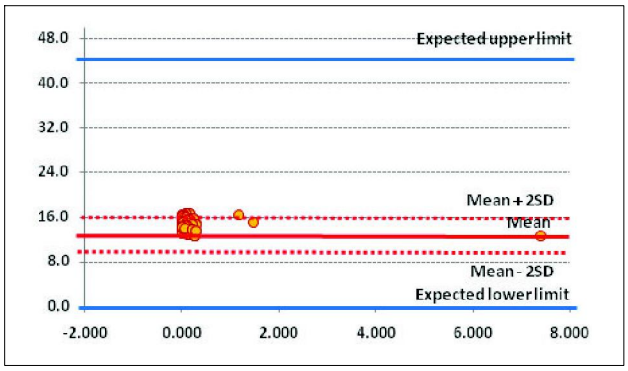

Figure 6: Blond Altman's comparative analysis for measured values and expected range for count rate (Kilo counts/second) in both detectors.

Blond Altman's comparative analysis of mean count rate of two detectors which shows minimal scatter around mean (within 2 SD) and these values are within NEMA limits although more closer to lower normal.

Statistical Analysis: Data was analyzed by using commercially available packages the Medcalc® statistical software version 11.3.10 and statistical package for social sciences (SPSS version 17®). A two-tailed student t-test was used to compare continuous variables and a chi-squared test was used to compare categorical variables. P value <0.05 were considered significant.

Discussion

Nuclear medicine imaging is critically dependent on the accurate and reproducible performance of imaging instrumentation. To ensure that performance of an imaging device is within a predefined acceptable range, an established set of ongoing measurements and analyses are employed which is called quality control (QC). This includes a comprehensive list of procedures recommended by NEMA (National Electrical Manufacturer Association) and the American Association of Physicists in Medicine (AAPM) which are time consuming.[4] In practice, however, less time-consuming and less rigorous procedures often suffice for day-to-day QC.

In this audit we performed we evaluated the camera performance parameters like background count detection, count rate and energy resolution following extrinsic (with collimators) protocol.

The reason for using extrinsic method was that it is less time consuming, safe and minimize the possibility of mechanical wear and tear at collimator and camera head interface. The background counts detected in this audit by both detectors were found within the benchmark and this entails no background or orphan radioactivity in the imaging suite. As a matter of safe practice we use to perform a facility survey at the end of working hours to find and discard any swab or body secretion (saliva) thrown by injected patients in imaging or waiting areas. The difference between detected values was although statistically significant but was well within NEMA standards as per vendor stance.

Gamma camera energy resolution may be evaluated by the percentage FWHM of the photopeak energy and energy resolution per se is often not routinely evaluated, the energy spectrum for each radionuclide used clinically should be checked at least once a day and ideally for each patient to verify that the photopeak is centered in the photopeak energy windows currently se3. Energy resolution of both detectors were also found within the benchmark However, difference between energy resolutions of two detectors were statistically significant. The primary reason for this difference was electronic drift between two heads and again was found within acceptable limits of NEMA.

We conclude that less time consuming and convenient procedures like background count, energy resolution and mean count rate measurement are sensitive tests for daily QC of a busy nuclear medicine department.

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