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Performance Characteristics of Spect Imaging System in Clinical Environment

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Abstract

Quality control has a fundamental role in the nuclear medicine before performing any medical examination to ensure the particular aspects of the procedure and to compliance the regulatory requirement. Optimizing the imaging equipment before clinical use, involves the measurement of radioactivity, selection of proper instrumentation, reconstruction technique and to perform the imaging study properly. The aim of this study is to assess the performance characteristics of dual head SPECT gamma camera installed at the nuclear medicine department of NORI, Islamabad.

Different methodologies have been developed by the manufacturer and various international organizations to evaluate the system performance. Radioisotopes involving Tc-99m, Co-57 and I-131 of different amount are used according to respective calibration measurements. Tests performed during studies include the measurement of system differential and integral uniformity, energy resolution, image resolution and linearity, center of rotation and sensitivity.

Results obtained by these experimental studies showed uniformity and energy resolution values are in the range and within limits recommended by IEC and AAPM. Center of rotation for each detector configuration is measured and found acceptable. Intrinsic resolution is found better compared to extrinsic resolution, sensitivity values were sustainable and good linearity behavior of gamma camera observed.

Introduction

Unsealed radioactive sources are used for diagnostic as well as therapeutic purpose to perform various kinds of procedures in nuclear medicine. The most commonly used radioisotopes in nuclear medicine at NORI are 99mTc and 131I having half life of 6 hrs and 8 days, respectively. Precision and accuracy in diagnostic studies can be achieved by understanding the standards of the techniques used for maintaining and optimizing the performance of the devices being used. The purpose of the present was to perform the acceptance testing of Siemens Symbia dual head gamma camera newly installed at NORI in order to evaluate its performance characteristics for clinical use. The research study was conducted to measure its performance on the basis of daily, weekly and monthly quality control tests. The recommended tests were carried out by applying IEC, NEMA and other international organizations protocols to ensure the scintillation camera is performing accurately to the specifications that are provided by the manufacture and compliance with the regulatory bodies [1-4].

The performance evaluation of the gamma camera was carried out in accordance to the recommended procedures and techniques of different professional organizations. In addition to these guidelines different protocols and workflows are locally developed to assess the performance of the system before using it clinically. This study is based upon not only on the test performance and the evaluation of results according to given protocols and recommendations but to fulfill the standards and results required on daily basis.

Material and Methods

The tests performed during study on the system are energy peaking of the detector, flood field uniformity, resolution of the

system, center of rotation and total SPECT performance. In addition to these procedures, regular QC processes, periodic tests are also carried out to evaluate in-depth details and performance characteristics of the system. All these tests provide data against system subsequent performance on weekly, monthly, quarterly and annually basis. Operational checks are carried out on daily basis to check performance of the instruments and detail records are maintained. The maintained records are useful for the comparative study and future reference [5-8].

Radioactive sources used to analyze the performance characteristics of SPECT system on the basis of performed tests were flood sheet source of 57Cobalt, point sources of technetium and iodine radioisotopes. Activity of the respective source is measured with dose calibrator and poured on a small piece of cotton approximately 3mm which is placed in the vial. It is essential for the point source preparation that the specific activity of the source must be high enough otherwise it may affect the results of gamma camera.

Different types of collimators are used for the extrinsic measurement studies of given Gamma Camera. Collimators common properties includes its thickness, maximum energy rating and it is hole angulations (diverging/converging hole). Quadrant bar phantom is used for measuring spatial resolution and distortion testing. It is for accurate measurements of camera intrinsic resolution, collimators spatial resolution, field size and linearity. Jaszczak SPECT phantom is used for the evaluation of total SPECT performance of the system. It is designed to evaluate the overall SPECT performance. The phantom is mainly useful for identifying whole degradation of the SPECT system. It measures the system resolution contrast and uniformity at the same time. A series of spheres and rods of variable diameters are present in the phantom [9-13].

Different source holders were used in performing the recommended tests. These source holders include, five points source holder, sheet source holder and integrated source holder. Five points source holder is designed for point sources used to perform different tests especially for the performance of COR and is also known as COR phantom. Whereas sheet source holder is specially designed for flood sheet source and is used mostly in extrinsic studies. Another Integrated source holder which is attached to the rear bed pallet located at the back of the gantry [10,11].

Results and Discussion

Acceptance tests of the SPECT system, Siemens Symbia Gamma Camera which is newly installed at NORI are performed and evaluated. Detail of the performed tests and corresponding results are given in this section.

Energy Peaking

Pulse height analyzer from the processing panel was used to perform the energy peaking of the system and radioactive 57Co source of 10 m Ci is used to evaluate the energy resolution of the system. Results obtained for energy peaking, window width and dead time for both detectors is given in Table 1.

Parameters	Detector1	Detector2
Width %	20	20
Peak shift %	1.35	1.27
Peak status	Peaked	Peaked
Dead time %	2.26	5

Table 1: Energy peaking and dead time for Detectors 1 and 2.

It is observed from the obtained results that energy window width for each detector is estimated about 20%. The measured peak shifts values obtained in the present study are 1.35 and 1.27 for detectors 1 and 2, respectively. The peak shift values are within the recommended limits (+3.0%). Dead time measured for detectors 1 and 2 found to be 2.26 and 5.00, respectively. These dead time values lie within the recommended range as given by the NEMA protocols.

Uniformity

Flood field uniformity evaluation includes both the integral and differential uniformity over central and useful fields of view. Results obtained for both detectors are shown in table 2. Data given in tables 2 showing calculated values of intrinsic and extrinsic uniformity calibration. Integral uniformity for detector 1 with CFOV and UFOV are 3.98% and 4.36 % respectively for intrinsic uniformity. Similarly, for differential uniformity, the results obtained for detector 1 are 1.80% and 2.37%. The results obtained for detector 2 having integral and differential uniformity for CFOV and UFOV found to be 4.09 %, 4.75% and 2.10%, 2.53% respectively. Extrinsic uniformity results for both detectors are also elaborated in Table 2.

		Intrinsic		Extrinsic	
Detector	Uniformity	Central field of view	Useful field of view	Central field of view	Useful field of view
1	Integral	3.98%	4.36%	3.22%	3.65%
	Differential	1.80%	2.37%	2.25%	2.31%
2	Integral	4.09%	4.75%	3.10%	3.92%
	Differential	2.10%	2.53%	2.03%	2.77%

Table 2: Integral and differential uniformities for detectors 1 and 2.

The calculated results for both detectors showing integral and differential values in table 2 for intrinsic and extrinsic uniformities are within range and acceptable limits. Differential uniformity values are less than the integral values as expected because differential uniformity measures the variation over the small field whereas integral uniformity is the measure of variation over the entire detector.

Center of Rotation

The Center of Rotation (COR) was performed for the verification of SPECT performance as well as for the mathematical formalism of tomographic image reconstruction. The study was performed for Low Energy High Resolution (LEHR) collimator which is commonly used for clinical studies. The COR test includes all detector configuration e.g. 76°, 90° 180° and acquired data displays a sinogram for visual inspection and calculated values for COR deviations. Tabulated form of the obtained results is given below in the Table 3.

Parameters	COR at 76^0		COR at 90^0		COR at 180^0	
	Detector 1	Detector 2	Detector 1	Detector 2	Detector 1	Detector 2
Center of rotation	-0.526 mm	-2.069 mm	-0.661 mm	-2.145 mm	-0.479 mm	-1.925 mm
Axial shift	-0.679mm	0.679 mm	-0.756 mm	0.756 mm	-0.493mm	0.493 mm
Back projection angle	-0.041^0	0.041^0	-0.022^0	0.022^0	-0.056^0	0.056^0
System resolution at 20 cm	18.008 mm	17.933 mm	22.431 mm	22.332 mm	14.667 mm	14.620 mm

Table 3: COR of the SPECT system at different angles.

Results obtained for both detectors configuration are acceptable and lies within the limits. System resolution is depending on the collimator used and obtained results for both of the detectors show COR values are acceptable. Regarding these results the system working especially for SPECT studies is considered normal and sustaining.

Resolution

A common approach for intrinsic and system resolution is the visual evaluation of the bar phantom images. The minimum distinguishable bar spacing in the acquired static phantom images is used as an index of camera spatial resolution. A quadrant bar phantom is used for performing the test to find out the resolution of the system. Images are acquired for both detectors as well as for intrinsic and extrinsic resolution with different angles. Images acquired with the bar phantom by rotating it 900 for each study to assess the linearity of both detectors are shown in figure 1. The acquired images show a resolution of the system which is acceptable and within the recommended limits.

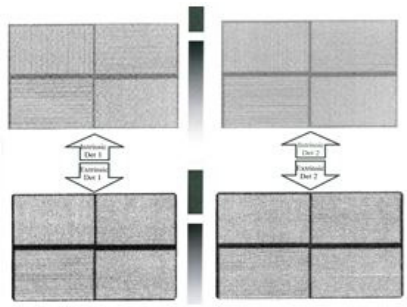

Figure 1: Intrinsic and extrinsic resolution of detectors 1 and 2.

Acquired images for intrinsic and extrinsic resolution are showing that intrinsic resolution images are better than the extrinsic images. Minimum intrinsic resolution is 2.5 mm whereas extrinsic resolution is 3 mm according to minimum distinct bar spacing on the phantom.

Total SPECT Performance

The test used for the assessment of overall SPECT performance in a single scan using Jaszczak phantom. This phantom has special design having spheres and rods that evaluates the resolution uniformity and its contrast at the same time. The results for Jaszczak phantom are shown in Figure 2.

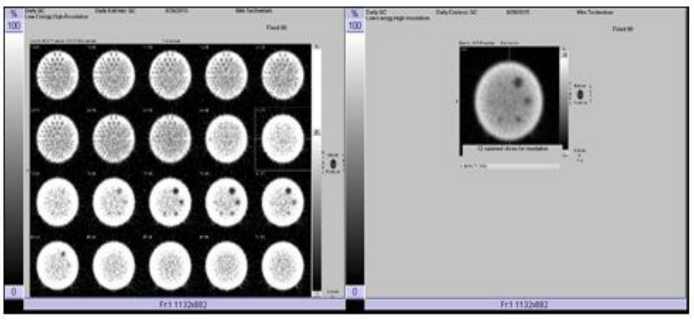

Figure 2: Jaszczak phantom images.

Visual evaluation of the obtained images shows that the area without spheres are uniform and no ring arte facts or any kind of non-uniformities are observed here. Cold area of spheres inside the phantom for system contrast is properly distinguishable and showing sustainable contrast for clinical studies. For system resolution out of six, five spheres are visible with the minimum resolution of 12.7mm. These images are consistent with the images obtained at the time of acceptance. So, it can be concluded from this study that system is optimum for the proper clinical performance.

Conclusion

The study was focused to analyze the performance of a newly installed SPECT system at NORI by carrying out acceptance testing before getting into its routine clinical use. Performance of the system was specified in terms of its energy peaking, unifor-

mity, center of rotation, resolution and linearity. Results obtained for energy peaking are acceptable as the measured peak shifts and dead time are within the recommended limits. System uniformity is within the recommended limits on the basis of calculated values. The results for center of rotation, axial shift, and back projection angle are within acceptable range for which the SPECT system working is considered sustaining. System resolution and linearity are evaluated visually which shows that intrinsic resolution is little better than extrinsic resolution whereas system linearity is showing good behavior which is sustainable for clinical use. The protocols and workflows developed locally are in routine use. Hence the system is accepted for clinical use on the basis of obtained results.

References

1. IEC-60789 (2005) Medical electrical equipment, Characteristics and test conditions of radionuclide imaging devices - Anger type gamma cameras.
2. IAEA Human Health Series No (2006) 6 International Atomic Energy Agency, Quality Assurance for SPECT Systems Vienna.
3. Siemens Operating Instructions Symbia System (2010) Quality Control and Assurance, T16/T6/T2/T Series, Version VA60A.
4. NEMA Standards Publication NU (1-2012) National Electrical Manufacturers Association, Performance Measurements of Gamma Cameras.
5. Zanzonico P (2008) Routine quality control of clinical nuclear medicine instrumentation. A brief review. J Nucl Med 49: 1114-1131.
6. Busemann SE, Płachcinska A, Britten A (2010) Routine quality control recommendations for nuclear medicine instrumentation. Eur J Nucl Med Mol Imaging 37: 662-671.
7. Bolstad R, Brown J, Grantham V (2011) Extrinsic Versus Intrinsic Uniformity Correction for gamma-cameras. J Nucl Med Technol 39: 208-212.
8. Bhatia B.S, Bugby SL, Lees JE, Perkins AC (2015) A scheme for assessing the performance characteristics of small field-of-view gamma cameras. Physica Medica 31: 98-103.
9. Bailey DL, Aswegen A, Van A, Humm JL, Todd PA (2014) International Atomic Energy Agency IAEA, Division of Human Health, Vienna Austria: 312-397.
10. Nichols KJ, Bacharach SL, Bergmann SR, Cullom SJ, Ficaro EP, et al. (2007) Links J, Inst quality Ass and perf. J Nucl Cardio 14: 61-78.
11. Muehllehner G, Wake RH, Sano R (1981) Standards for performance measurements in scintillation cameras. J Nucl Med 22: 72-77.
12. Murphy PH (1987) Acceptance testing and quality control of gamma cameras, including SPECT. J Nucl Med 28: 1221-1227.
13. Alehyani SHA (2009) Application of single photon emission computed tomography (SPECT) parameters for bone scintigraphy. J King Saud Univ Sci 21: 109-117.