Effect of Counts per Image on the Gamma Camera Uniformity

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Abstract

Studies on gamma camera uniformity, showed that: $4x10^6$ (4 M) counts per image were found to be the lowest number of counts required to define the non- stochastic response of the gamma camera used. (T-test, $p \leq 0.05$).
Further studies were recommended.

INTRODUCTION

Evaluation of detector non-uniformity is the most common practice in present day quality control procedures. With the methods suggested by NEMA (National Electrical Manufacture Association) and IAEA (International Atomic Energy Agency), camera uniformity was evaluated at conditions that are not representative of clinical images; such conditions are counts per image, use of collimated detector, distance between collimated detector and source and presence of scattering medium. In an attempt to bridge this gap, factors affecting system uniformity using the methods suggested above were studied. Studies were carried; investigation of the variation of uniformity with count per image without scattering medium. For this study the data being acquired on 256x256 matrixes, the window width was kept fixed at 20%, the ZLC-37 Siemens gamma camera modified by Mediso, at the Radiation and Isotopes Center in Khartoum (RICK) was used. NEMA (1988) and IAEA (1991) approach for the measurement on the uniformity was followed.

EXPERIMENTAL PROCEDURE & RESULTS

The computerized gamma camera system (ZLC- 37 Siemens gamma camera modified by Hungarian Mediso) of Radiation & Isotopes Center in Khartoum (RICK), was used in this study. This camera has a 37 photo multiplier tubes (PMTs) and a crystal made of activated thallium sodium iodide {NaI (TL)} with a diameter of 400 mm and a thickness of 10 mm. Two Pentium computers were connected to the gamma camera; the first one used for acquisition and the second one used for processing the acquired data by using a program called Macros within the special software Nuclear Imaging System (DIAG). The processed data can then be displayed on the monitor and a hard copy can be obtained using a Laser Jet- 6L Color printer.

A (20) MBq Co-57 (half-life =270 days and emits photons of energy = 122 keV) point source was used for intrinsic uniformity studies. The source was placed at a distance of about 5 field of view (5FOV) from the uncollimated detector. The count rate recorded was less than 20 k counts per second.

A (200) MBq Co-57 disc type flood source was used for all system uniformity studies. When placed on top of collimated detector, a count rate of less than 30 k counts per second were recorded. The low energy all-purpose collimator (LEAP) was used in this study.

Tables (1&2) and figs (1&2) shows the variation of uniformity indices with increase of counts. The uniformity indices for both intrinsic and system uniformity were not significantly different for counts between 4M and 16M counts per image. However significant variation could be seen for counts less than 4 M counts per image. The statistical student test (t-test, $p \leq 0.05$), was used to study the effect of counts per image on uniformity. The results are shown in table (3).

Figure 1

Table 1: (UFOV) Differential & Integral Intrinsic Uniformity

M Counts	0.5	1.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
Diff. Uni.	8.0	4.5	3.5	2.5	2.3	2.1	2.2	1.7	1.8	1.5
Int. Uni.	10.5	6.0	5.4	3.6	3.2	2.6	2.3	2.6	2.1	2.4

Figure 2

Table 2: (UFOV) Differential & Integral System Uniformity

M Counts	0.5	1.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0
Diff. Uni.	6.3	5.4	4.7	3.5	3.6	3.2	3.4	2.9	3.0
Int. Uni.	9.1	7.6	7.0	5.9	6.2	6.0	5.7	5.9	5.3

Figure 3

Table 3: Confidence Terminals

The Uniformity	X	X_{min}	X_{max}
Intrinsic Diff. Uni. (16 M counts/ image)	1.5	0.36	2.64
Intrinsic Int. Uni. (16 M counts/ image)	2.4	0.88	3.92
System Diff. Uni. (14 M counts/ image)	3.0	2.22	3.78
System Int. Uni. (14 M counts/ image)	5.3	4.43	6.17

Effect of Number of Counts on the Uniformity

Figure 4

Figure 1

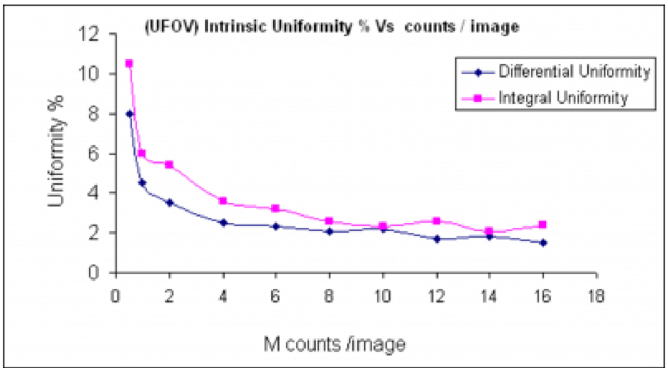
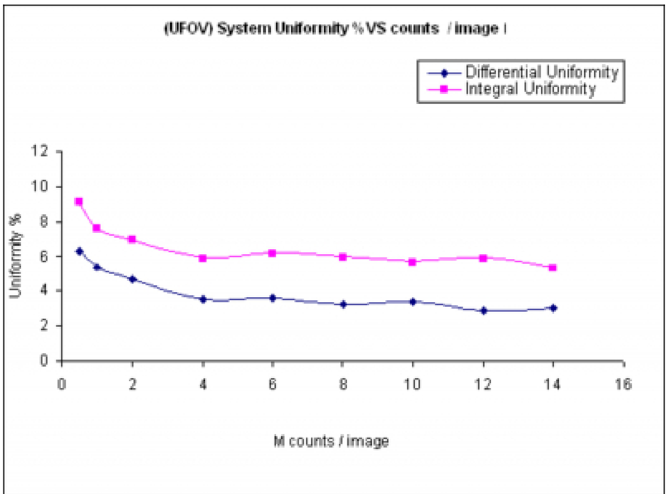


Figure 5

Figure 2



DISCUSSION

The non- uniformity in flood image is susceptible to variations in a number of performance parameters. For this reason, evaluation of camera uniformity represents a method of monitoring system performance [15]. The fluctuations of count density in the flood image are produced not only by the variation of the camera performance but also by statistical variations due to the stochastic nature of the radioactive decay. This statistical noise is reduced as the image count density is increased, with the result that non-stochastic variations in camera response are more accurately defined (Sharp1988). In order to diagnose degradation in system performance before clinical image, it is necessary to collect flood data with sufficient statistical accuracy to define the non- stochastic response. Results displayed in Fig (1&2) and table (3) indicate that counts per image ≥ 4M counts per image acquired on 256 x 256 matrix are sufficient to define the non- stochastic response. In a similar study, but for three different gamma cameras Sharp (1988), showed that 30 M counts per image acquired on 64 x 64 matrix were required for this purpose. The effect of using different matrix size has not been considered. The discrepancy between the two results may be attributed to the variations in the detector non- uniformity of the different cameras. Therefore medical physicists should be encouraged to specify the lowest number of counts per image and the matrix size to define the non-stochastic response for their cameras as an acceptance test. In this study 4M counts per image may be regarded as the lowest number of counts per image to define these response of the camera. This has the advantage in reducing the time to perform the daily assessment of uniformity in hospitals to 4 mints rather than the 25 mints obtained by Sharp (1988) at a typical count rate of 20 k counts per second.

CONCLUSION & RECOMMENDATIONS

The studies carried on the uniformity of the Siemens ZLC-37 modified by Mediso gamma camera showed that; 4 M counts per image were found to be the lowest number of counts per image that defines the non- stochastic response of the camera, and therefore reduce the time for the daily quality control for uniformity to 4 mints at count rate of 20 k counts per second. It is recommended that, further studies should be carried to see the effect of energy and window width on uniformity. Also further studies were recommended to test the effects of the correction circuitry when a known non- uniform source was used.

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