Effect of Different Parameters on Intrinsic Uniformity Test For MEDISO Single-Head Gamma Camera

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ABSTRACT

The most basic and sensitive routine quality control (QC) of gamma camera is that of intrinsic uniformity. Intrinsic uniformity must be assessed daily and after each repair, it must be critically evaluated and any necessary action must be undertaken before using the gamma camera for patient imaging.

The main objective of this work is to determine the best parameters for daily quality control testing of intrinsic uniformity for the single-head gamma camera from MEDISO Company installed at Institute of Nuclear Medicine - University of Gezira.

Intrinsic uniformity test was done by placing a point source $^{99m}TcO^{-}$ (^{99m}Tc) in front of the detector with removed collimator to measure the effect of correction matrix, source-to-camera distance, a count rate and activity volume on intrinsic uniformity.

The results showed that the best intrinsic uniformity image obtained at distance of 100 cm, with correction matrix, activity volume in range of 0.1 - 0.4 ml in 3 ml syringe and count rate between 25 - 30 kcps which took less than 14 min to get uniform image.

Keywords: single-head planer gamma camera; intrinsic uniformity; collimator; quality control (QC); Kilo Count Per Second (kcps); correction matrix; count rate; activity volume; point source.

INTRODUCTION

Uniformity test is the most common practice in present gamma camera quality control procedures, suggested by NEMA (National Electrical Manufacture Association), IAEA (International Atomic Energy Agency) and IEC (International Electro technical Commission) (IAEA, 1991, NEMA, 2001 & IEC, 1998). Uniformity is a measure of camera's response to uniform irradiation of the detector surface. The ideal response is a perfectly uniform image (Bushberg et al., 2002).

Earlier cameras used thicker light guides and large-diameter photomultiplier tubes (PMTs), in part to achieve satisfactory uniformity, at the expense of somewhat degraded spatial resolution. Because of effective uniformity corrections, newer cameras can use thinner light guides and smaller PMTs, both of which contribute to more accurate event localization and improve intrinsic special resolution (Simon et al., 2003).

Field uniformity test can be done intrinsic or extrinsic. Intrinsic without collimator to monitor the condition of sodium iodide crystal and electronics and extrinsic with collimator to monitor the camera as it is used clinically (Lectures, 2006). Intrinsic uniformity testing was preferred because a ^{99m}Tc point source is readily available at our institute.

Intrinsic uniformity test was done with a point source (typically 11.1 MBq of ^{99m}Tc) positioned in front of the uncollimated camera. The source was placed into the lead box with copper filtration of 2 mm. The uniformity of the camera is a sensitive indicator of camera performance and should perform daily for homogeneity before patient imaging.

The flood uniformity image can be evaluated numerically or graphically (Murphy, 1987). The NEMA protocol for intrinsic flood field uniformity analyses both differential uniformity and integral uniformity. Differential uniformity is a measure of maximum rate of change over a short distance and integral uniformity is a measure of maximum deviation. The integral uniformity represents the maximum pixel count rate change over the indicated field of view expressed as percent. The differential uniformity is the maximum change over a five pixel distance in the X or Y direction thereby representing the maximum rate of change of regional count rate (Muehllehner, 1981).

MATERIAL AND METHODS

The following procedure was used to measure the system intrinsic uniformity and determined the parameters affect image uniformity. Gamma source activity, source holder, copper plates, source-to-camera distance, count per second, uniformity with & without correction matrix and source volumes were evaluated to determine the ideal parameters for our daily quality control in the department (Department of Medical Physic and Instrumentation).

1- The collimator was removed from the camera and the detector was set with its face towards the ground.
2- 3 ml syringe was used as a point source, laid in the middle of the source holder; the volume was varied between 0.1 - 1.0 ml.
3- Source holder seated on the gantry arm facing the centre of detector with varied distance.
4- Camera surface and the room were cleaned to insure there was no contamination, then the room background was measured by NaI crystal gamma camera, it was 140 cps after removing all available sources from the room. The contamination affects the gamma camera performance, unless measurements of uniformity are performed with a medium or high energy collimator (Connor et al, 1999).
5- The point source was carefully aligned in the centre of the camera. The distance between the point source and the camera detector was varied between 85 cm - 120 cm (maximum distances) to determine the effect of the source distance on intrinsic uniformity test.
6- NEMA (2001) and IAEA (1991) approach for the measurement of intrinsic uniformity was followed.
7- The intrinsic uniformity of the camera (Differential uniformity & Integral uniformity) was determined using InterView and DIAG software provided by the manufacture (Mediso Medical Imaging System) where the maximum and minimum pixel values determined.
8- A 20% energy window set symmetrically over the ^{99m}Tc photopeak is equivalent to 140 ± 10 % keV or a window spanning 126 - 154 keV.
9- The manufacture's instruction was followed initially for the quality control test.

RESULTS & DISCUSSIONS

Intrinsic Uniformity Versus Source-to-Camera Distance

Figure (1) shows the differential uniformity and integral uniformity of the machine versus the source-to-camera distance where the count rate increased with decreasing the distance and decreased with increasing the distance. Figure (1) shows that both differential and integral uniformity improved in source-to-camera distance in between 95 - 105 cm, the best result was obtained at a distance of 100 cm.

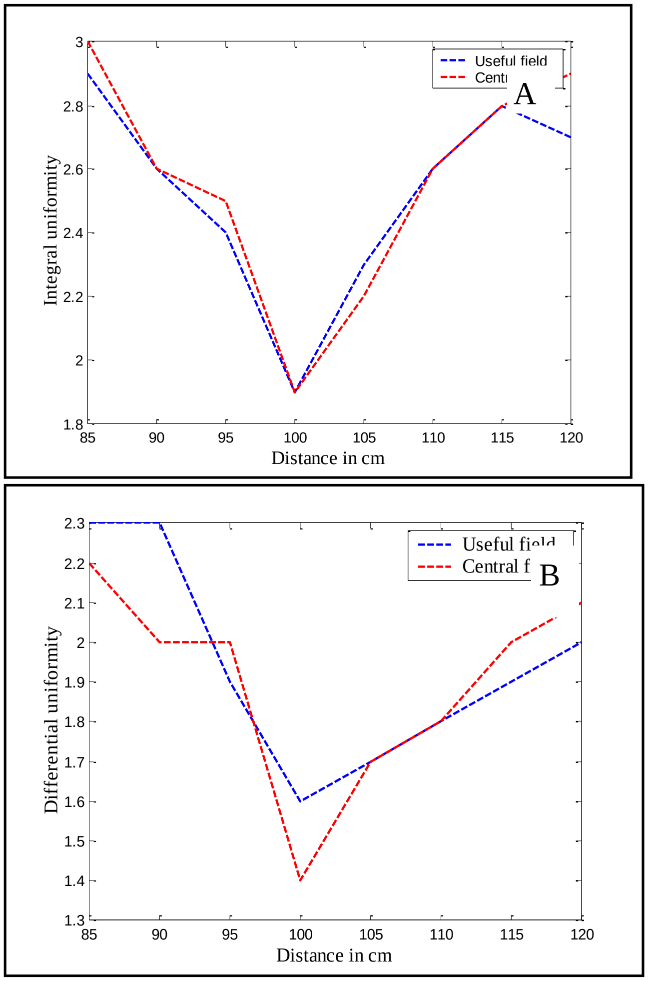

Fig. 1: Intrinsic uniformity versus source-to-camera distance, (A) distance versus integral uniformity (B) distance versus differential uniformity. The best values of intrinsic uniformity were at a distance of 100 cm.

Intrinsic Uniformity With & Without Correction

The intrinsic uniformity has been repeated several times with and without correction matrix. The result from Fig. (2) Showed that the best values for differential & integral uniformity with correction matrix.

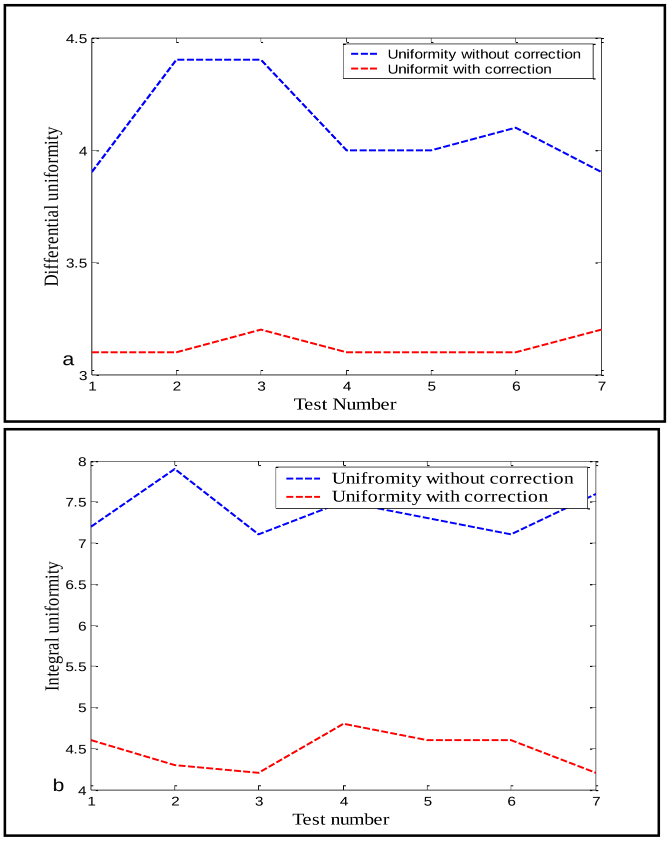

Fig. 2: Intrinsic uniformity test with and without correction matrix. (a) Differential uniformity, (b) Integral uniformity. The intrinsic uniformity for both differential and integral were within the range (acceptable) with correction but out of range without correction (not acceptable).

Intrinsic Uniformity versus Activity Volume

Figure (3) shows the experimental intrinsic uniformity (Differential & Integral) of the camera at different source volumes. The ^{99m}Tc activity was 11.1 MBq (300μCi), a count of 25 kcps and distance of 100 cm. The figure shows a constant intrinsic uniformity for the volume between 0.1 – 0.4 ml and then was changed when the volume increased.

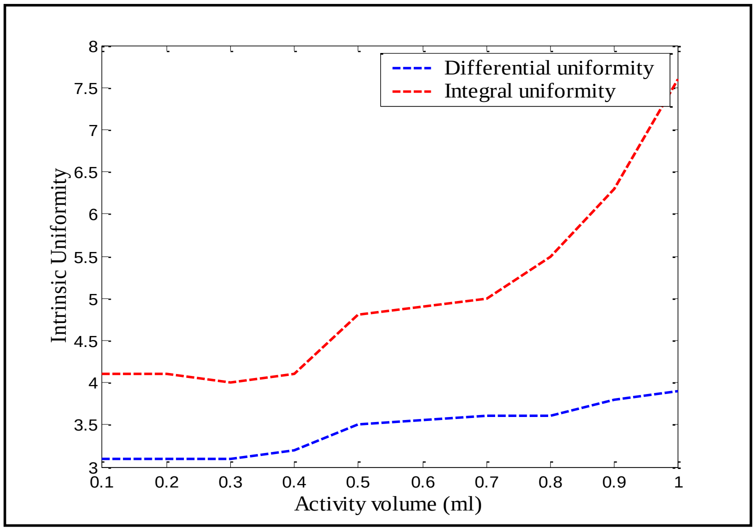

Fig. 3**:** Intrinsic uniformity versus activity volume. The intrinsic uniformity was constant for source volume up to 0.4 ml.

Intrinsic Uniformity Count Rate versus Uniformity Time

Figure (4) shows the calculated time and the actual time for the intrinsic uniformity test. The time was calculated by:

$$Calculated\ Time = Total\ count/count\ per\ second \qquad (1)$$

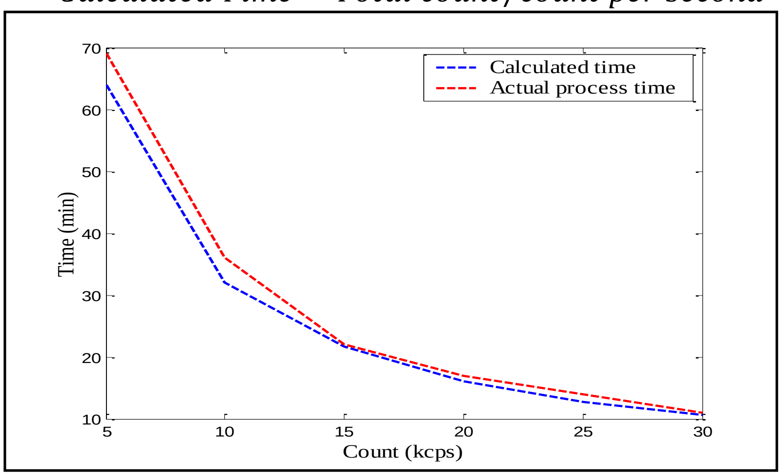

Fig. 4**:** The relation between the time and count rate. The difference between calculated time and actual process time was very small

From Fig. (4)it could be concluded that :

1- There was a small difference between the calculated time and actual processing time.
2- The processing time decreased when increasing the count rate, the suitable range was between 25 - 30 kcps to get the best uniform image and save time (11 - 14 min). To achieve this count rate, the source activity must be more than 10.36 MBq (280 μCi) and less than 11.84 MBq (320 μCi).

CONCLUSION

Various agencies, companies and authors (IAEA 1991, NEMA 2001, IEC 1998, Connor et al, American Association of Physicists in Medicine 1980 & Mediso Medical Imaging System 1995) have suggested many protocols for gamma camera quality control, there was no significant difference between our parameters and the suggested protocols, see table (1), the differences were most probably due to setting and environmental changes. We have used this protocol (parameters) for our daily planar gamma camera quality control (QC) during last nine months. It took 11 - 14 min, with count rate of 25 - 30 kcps, activity volume between 0.1 - 0.4 ml and a distance between 95 - 105 cm (at 100 cm was perfect). Above all intrinsic uniformity has to be done with matrix correction.

Table. 1: The standard Uniformity test as recommended by company and authors and our test values at ideal distance.

Test / Company & Authors	Differential uniformity		Integral uniformity	
	Useful field %	Central field %	Useful field %	Central field %
Swiss standard	1.4	1.2	2.1	2.0
Mediso Company	1.5	1.4	1.8	1.8
Our test	1.6	1.4	1.9	1.9

REFERENCES

American Association of Physicists in Medicine - Nuclear Medicine Committee. (1980). Scintillation Camera Acceptance Testing and Performance Evaluation. AAPM Report No. 6. *American Institute of Physics.*

Baechler, S.. et al. (2005). Feasibility of the Gamma Camera Acceptance Testing Procedure Introduced by the Swiss Federal Office of Public Health. *Swiss Federal of Public Health. Swiss.*

Bushberg, J. et al. (2002). Essential Physics of Medical Imaging. 2nd edition. *USA* IAEA TECDOC-60. (1991). Quality Control of Nuclear Medicine Instruments.

Chiesa. C. (2005). Quality issues with nuclear medicine equipment: gamma cameras. *Annual Congress of the European Association of Nuclear Medicine. Istanbul.*

Elkamhawy, A. et al. (2000). Intrinsic Uniformity and Relative Sensitivity Quality Control Tests for Single-Head Gamma Cameras. *J. Nucl. Med. Vol. 28. No 4. 252 –256.*

IAEA TECDDOC 60 (1991). Quality control of nuclear medicine. Medicine Instruments

International Electro technical Commission. IEC Standard 61675-2. (1998). Radionuclide Imaging Device – Characteristics and Test Condition. Part1. Single Photon Emission Computed Tomography. *International Electro technical Commission. Switzerland, Geneva.*

International Atomic Energy Agency (IAEA). (2003). IAEA Quality Control Atlas for Scintillation Gamma Systems. *International Atomic Energy Agency, Vienna.*

IPEM Report 86 (2003). Quality Control of Gamma Camera System. *Fairmount House, 230 Tadcaster Road York YO24 IES UK.*

Mediso Medical Imaging System. (1995). Product Document for Single-Head Gamma Camera, Revision 1.02. *Mediso, Budapest*.

Muehllehner, G.; R. Wake, and R. Sano. (1981). Standard for Performance Measurement in Scintillation Cameras. *J. Nucl. Med. Vol. 22. 72 - 77.*

Murphy, P. H. (1987). Acceptance Testing and Quality Control of Gamma Camera's. Including SPECT. *J. Nucl Med. vol. 2. No. 7. 1221 - 1227.*

NEMA Standard Publication NU 1-20N01. (2001). Performance Measure-ments of Scintillation Cameras, *National Electrical Manufacturers Association, Rosslyn, USA.*

O'Connor, M. et al. (1999). Quality Control of Scintillation cameras Planar and SPECT. http://www.aapm.org/meetings/99AM/pdf/2741-51264.pdf.

Peter F. Sharp, Howard G. Gemmell, Alison D. Murray. (2005). Practical Nuclear Medicine. 3rd edition. *Springer – Verlag, London.*

Scintillation Camera quality control. (2006). Scintillation Quality Control Lecture-3-Product Training/Manual. *htt://www.authorstream.com /presentation.*

Simon, C.. ; P. Michael and S. James. (2003). Physics in Nuclear Medicine. 3rd ed. *Saunders Co. Philadelphia.*

تاثير العوامل المختلفة على الإتساق الجوهرى لعملية ضبط جودة جهاز التصوير باشعة القاما أحادى الراس

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الملخص

الإتساق الجوهرى (Intrinsic Uniformity) من اهم الاشياء التى يمكن بها مراقبة جودة وحساسية جهاز التصوير باشعة القاما. يتم إجراء الاختبار يومياً وبعد أي صيانة تتم بالجهاز، يجب إجراء هذا الإختبار بدقة فائقة قبل إستخدام الجهاز لتصوير المرضى.

الغرض من هذا العمل هو تحديد انسب العوامل لإختبار مراقبة الجودة اليومى للإتساق الجوهرى لجهاز التصوير باشعة القاما أحادى الرأس بالمعهد القومى للسرطان - جامعة الجزيرة.

تم إجراء الإختبار بوضع نقطة من المصدر المشع امام كاشف (Detector) تم نزع الحاجز الرصاصى (Collimator) عنه لقياس اثر كل من بعد المصدر المشع عن الكاشف، مصفوفة التصحيح، نسبة الإحصاء وحجم المادة المشعة على الإتساق الجوهرى.

اظهرت النتائج ان افضل صورة للإتساق الجوهرى تم الحصول عليها عندما كان المصدر المشع على بعد 100 سم، بواسطة مصفوفة التصحيح، حجم المادة المشعة مابين 0.1 - 0.4 مل ونسبة احصاء ما بين 25- 30 kcps. تم إجراء الإختبار فى فترة زمنية لا تتجاوز 14 دقيقة.