A New Technique for Reduction of Scattered Gamma Photons in Tc-99m SPECT Imaging

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Inayatullah Shah Sayed[1]*, Ahmad Zakaria[2] and Tuhin Haque[2]

[1]School of Health Sciences, [2]Department of Nuclear Medicine, Oncology and Radiotherapy, School of Medical Sciences, Universiti Sains Malaysia, Kubang Kerian, Kota Bharu, Kelantan

*Present address: Faculty of Allied Health Sciences, International Islamic University Malaysia, Kuantan Campus, 25200 Kuantan, Pahang Darul Makmur, Malaysia

Phone: 09-5716400 Ext. 2607 Fax: 09-5716776, E-mail: inayatullah@iium.edu.my

ABSTRACT

In healthcare, the prime objective prior to cure any disease is accurate diagnosis of abnormalities in humane. There are different diagnostic procedures and techniques. In this regard, imaging techniques play a potential role. Single Photon Emission Computed Tomography (SPECT) imaging is one among them. The technique uses some gamma photon emitting radionuclides and it is applied worldwide as an important diagnostic imaging tool. However, the technique has some limitations, e.g., equipment related, absorption and scattering of gamma photons within the patient body. Scattering of gamma photons degrade the system spatial resolution. Consequently, image quality is degraded and quantitative accuracy of radioactivity distribution is limited. This work attempts to reduce the effects of scattered gamma photons from SPECT images. There are some scatter correction techniques and each technique has limitations in one or another way. A unique technique has been introduced to absorb some fraction of scattered gamma photons from the image raw data before their registration. The technique uses thin sheets of materials; copper and aluminum as physical filters. SPECT data are acquired by using Toshiba GCA 901 A/HG gamma camera. Carlson's phantom filled with water is used. Cold and hot regions inserts are placed in the phantom. Tc-99m radionuclide is uniformly distributed in the phantom. Either LEGP or LEHR collimators are used. Data acquisition parameters are chosen as those are selected for patient studies. Data are acquired with and without physical filters. Images are reconstructed by FBP reconstruction technique with Butterworth filter. Chang's attenuation correction technique is applied for compensation of absorption of gamma photons. Images obtained with and without physical filtered data are analyzed and compared in terms of perceived image quality, hot and cold region detectability and image contrast. Results show that, perceived image quality, hot and cold region detectability and image contrast is improved when physical filters are used. This suggests that the technique may have potential applications in clinical studies.

BACKGROUND

Nuclear medicine imaging is a non-invasive radionuclide technique which is widely used for diagnosis of abnormalities in patients. In clinical studies, it is always desired to obtain better quality images and accurate quantitative information from the gathered data, in order to provide better diagnostic and treatment services to patients. Quality of images and quantitative accuracy of clinical data primarily depends upon performance parameters of gamma camera, such as, energy resolution, spatial resolution, over all sensitivity, uniformity and linearity.

There are some factors that affect performance parameters of gamma camera systems. Scattered gamma photons are among those factors. Presence of scattered gamma photons in the image data results the overall degradation of image quality. Also makes quantitative information unreliable if data are not corrected for.

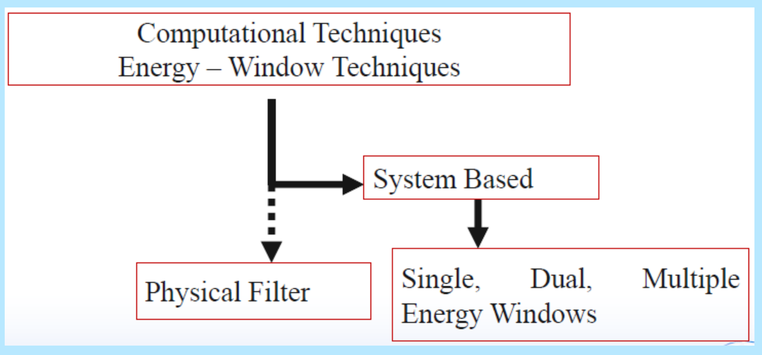

Fig. 1 Approaches towards scatter correction

Another approach for the improvement of performance of scintillation camera systems is the use of unconventional (material) filters. In nuclear medicine planar imaging - Muehllehner et al (1974) and Pillay M et al (1986) applied an alloy filter consisting of Lead (Pb), Zinc (Zn), and Tin (Sn). In single photon emission computed tomography (SPECT), Shah SI (1996) used a Tin (Sn) material sheet 0.25 mm thick.

Objective of this work is to tackle the scatter problem in Tc-99m SPECT imaging by the use of unconventional (Physical) filters and to investigate the effects on, hot and cold region detectability, perceived image quality and image contrast. In this study, Cu 0.125 mm, Al 0.2 and 0.3 mm thick sheet(s) is/are applied.

MATERIALS AND METHODS

For SPECT data acquisition, Toshiba GCA 901A/HG gamma camera either with LEGP or LEHR collimators is used. R. A. Carlson's phantom filled with water and hot / cold regions inserts are placed in the phantom tank. Radioactivity Tc-99m is distributed.

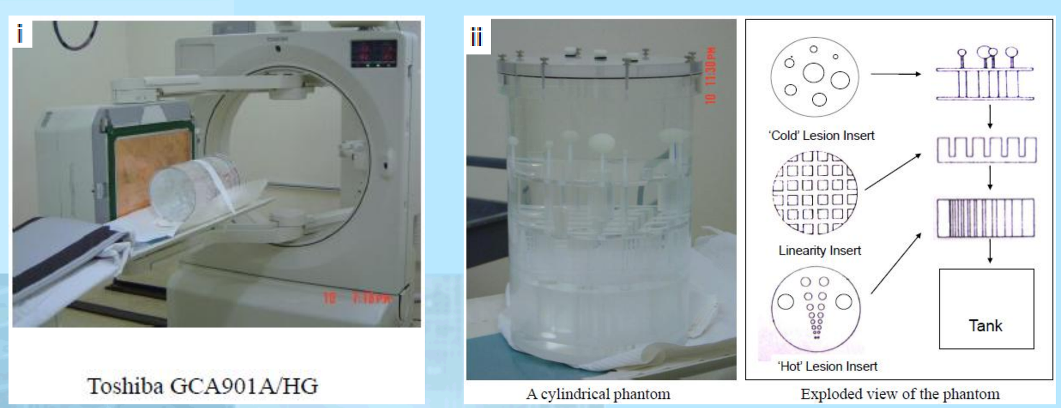

Fig. 2 (i and ii). Gamma camera (i) and R. A. Carlson's Phantom (ii)

Data are acquired within a symmetrical energy window 20% (centered at 140 keV) with and without unconventional filters (Cu 0.125 mm and Al 0.2 and 0.3mm sheets). Sixty views are taken over 360° anti clockwise rotation and the time for each projection/view is 20 seconds. Image matrix 128 x 128. Images are reconstructed by the filtered back projection method. Chang's method is used for the attenuation correction . All data are corrected for the decay of Tc99m, uniformity and center of rotation (COR).

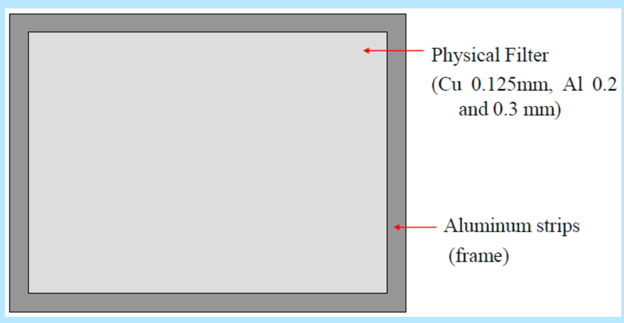

Fig. 3 Construction of physical filter(s)

RESULTS AND DISCUSSION

Energy resolution for most systems is approx: 8 - 12% for 140 keV energy gamma photons. Hence, no total scatter rejection via energy discrimination (20% window). Approx: 20 - 40% of the detected events in SPECT data are present due to scattered photons [Larsson et al (1986)]. 70 – 80 % of the total scatter in 126 – 154 keV window is present in the region of 126 – 139 keV [Kojima et al (1991)].

The new SPECT scatter reduction technique introduced here absorbs some fraction of scattered gamma photons prior to their registration in the image data. Hence, it may be called as "pre processing" scatter reduction technique. Other advantages are, filter material is easily available, low cost, easy to mount on surface of the gamma camera collimator, low weight.

Working of the technique is explained by the following figure.

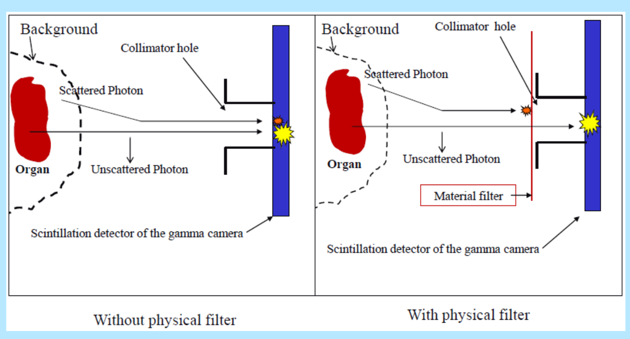

Fig. 4. Working of a physical filter

Analysis of hot and cold region detectability, perceived image quality and image contrast.

Hot region analysis: Figure 5(i) shows the transverse slices of hot regions insert in a uniform cold background with LEGP collimator. In figure 5(i) B, C and D more hot regions can be seen clearly as compared with the image 5(i)A. There is little blurring around all the hot regions [5(i) B, C and D] related to image 5(i) A. This suggests that scattered gamma photons have been absorbed by the physical filter. The gap between the smaller diameter hot regions is not that obviously visible though the blurring effect is reduced with the physical filter.

Figure 5(ii) shows the image contrast of different sized hot regions. Improvement in image contrast of hot regions is achieved with physical filter as compared to without filtered data images.

The same trend is observed in the results of hot regions obtained with the LEHR collimator as shown in Figure 6(i and ii).

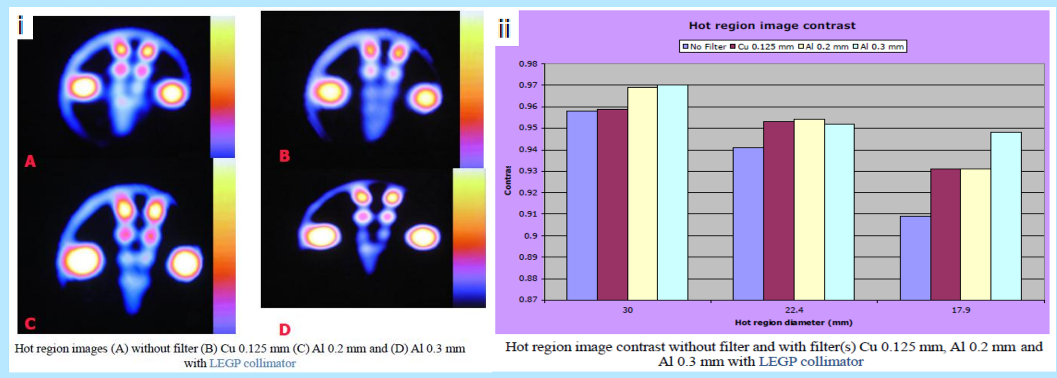

Fig. 5(i and ii) Hot regions detectability and image contrast with and without physical filter- LEGP collimator

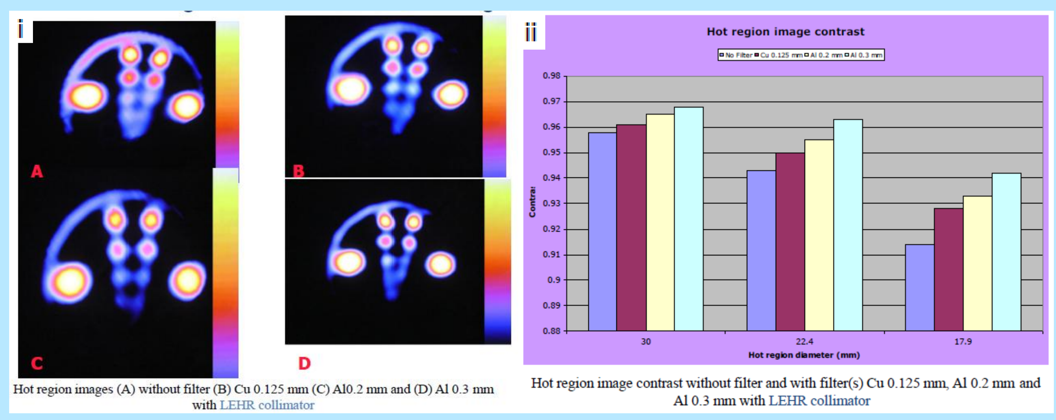

Fig. 6(i and ii) Hot region detectability and image contrast with and without physical filter- LEHR collimator

Cold region analysis: Figure(s) 7(i) and 8(i) indicates reduction in the effects of scattered gamma photons on images. Also cold region detectability is improved using physical filters with LEGP and LEHR collimators installed on gamma camera. Figure(s) 7(ii) and 8(ii) shows image contrast values. A significant contrast enhancement has been recorded with physical filters as compared to no filter is used – LEGP and LEHR collimators.

Further, comparing the collimators, LEHR provides better results as compared to LEGP collimator with physical filter.

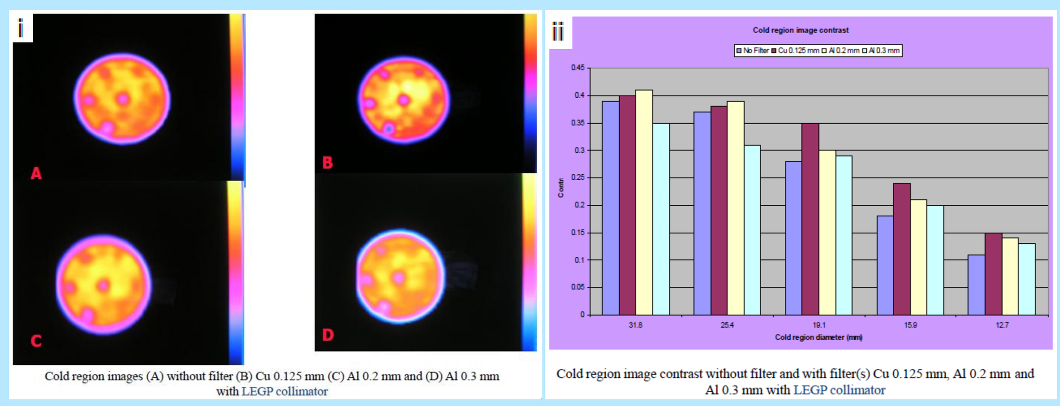

Fig. 7(i and ii) Cold region detectability and image contrast with and without physical filter- LEGP collimator

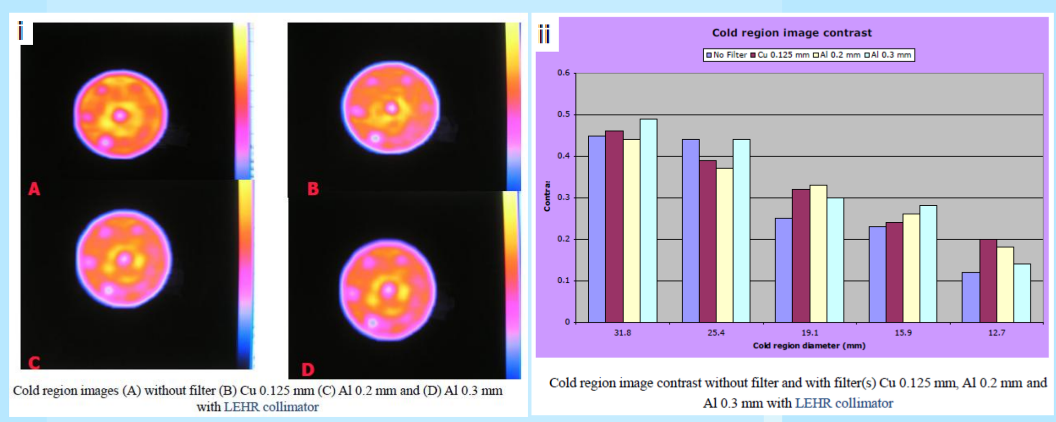

Fig. 8(i and ii) Cold region detectability and image contrast with and without physical filter- LEHR collimator

CONCLUSION

Findings indicate improvement in parameters those were investigated when physical filters are used, e.g., hot and cold region detectability, perceived image quality and image contrast. Therefore, the technique may have important applications in clinical studies.

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