Collimator and Energy Window Optimization for Practical Imaging Protocol of Y-90 Bremsstrahlung SPECT/CT: A Phantom Study.

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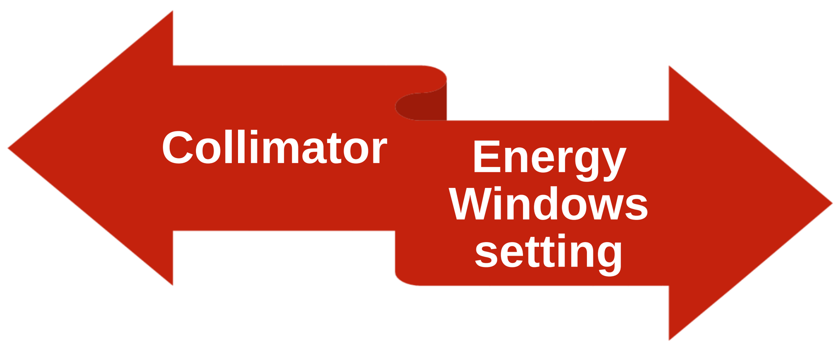
Objective

- To improve Yttrium-90 (Y-90) bremsstrahlung imaging protocol and quantitative accuracy of planar scintigraphic imaging and SPECT for our hospital by optimizing



Introduction

Y-90 is effectively a pure beta emitter, i.e., it lacks discrete energy photon emissions, such as gamma rays and/or characteristics fluorescence x-rays. The x-ray photons emitted by Y-90 are very low in both yield and energy (≪18 keV), and the gamma photons emitted by Y-90 have an insignificant yield and very high energy (~2 MeV). Y-90 activity distribution *in vivo* is traditionally assessed by imaging the bremsstrahlung photon, which is produced from interactions of energetic beta particles with soft tissue, using planar and/or SPECT/CT imaging.

Y-90's lack of photopeaks has stunted standardization of Y-90 bremsstrahlung imaging procedures; consequently, image quality varies widely amongst different facilities. The continuous nature of Y-90 photon emissions prohibit the straightforward approach of centered the energy window (EW) on the photopeak and its extend (width). Research on improving Y-90 bremsstrahlung imaging is ongoing.

Methods and Materials

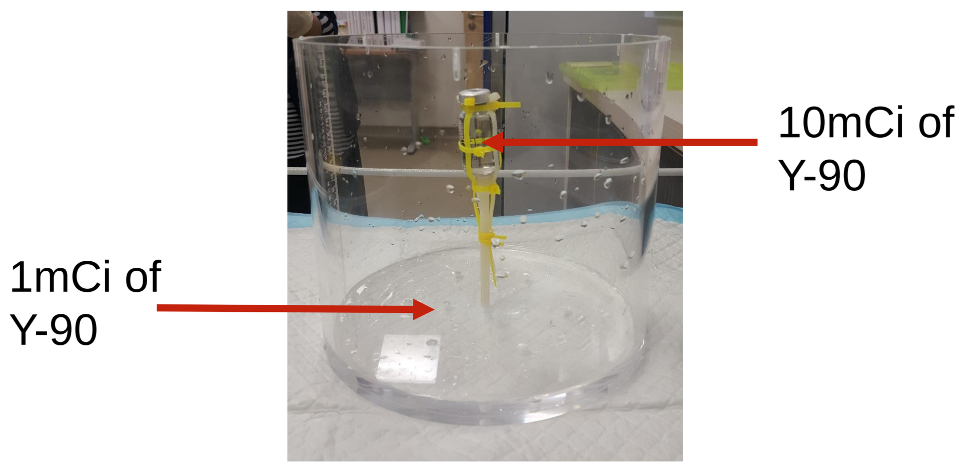


Figure 1. Customized phantom

A cylindrical phantom with a vial fixed at the center was prepared and positioned at Symbia Intervo SPECT/CT systems (Siemens Medical Solution, Hiffman Estates, IL, USA).

Planar static images were acquired for each imaging conditions at the matrix size of 256 x 256 and1 x10^6 counts.

Table 1. Summary of the imaging conditions acquired.

	Collimator	Energy windows
A	LEHR	200 keV (50%)
B	LEHR	80 keV (50%) 120 keV (30%)
C	LEHR	80 keV (50%) 120 keV (30%) 200 keV (50%)
D	MEGP	200 keV (50%)
E	MEGP	80 keV (50%) 120 keV (30%)
F	MEGP	80 keV (50%) 120 keV (30%) 200 keV (50%)
G	HEGP	200 keV (50%)
H	HEGP	80 keV (50%) 120 keV (30%)
I	HEGP	80 keV (50%) 120 keV (30%) 200 keV (50%)

All the images were analyzed and evaluated based on image quality, signal-to-background ratio (SBR) and coefficient of variation (CV).

Results

Table 2. SBR and CV for each imaging conditions.

	SBR	CV
A	0.35	0.17
B	4.39	0.25
C	4.63	0.25
D	8.54	0.40
E	11.06	0.50
F	11.54	0.42
G	10.08	0.52
H	16.40	0.44
I	17.08	0.35

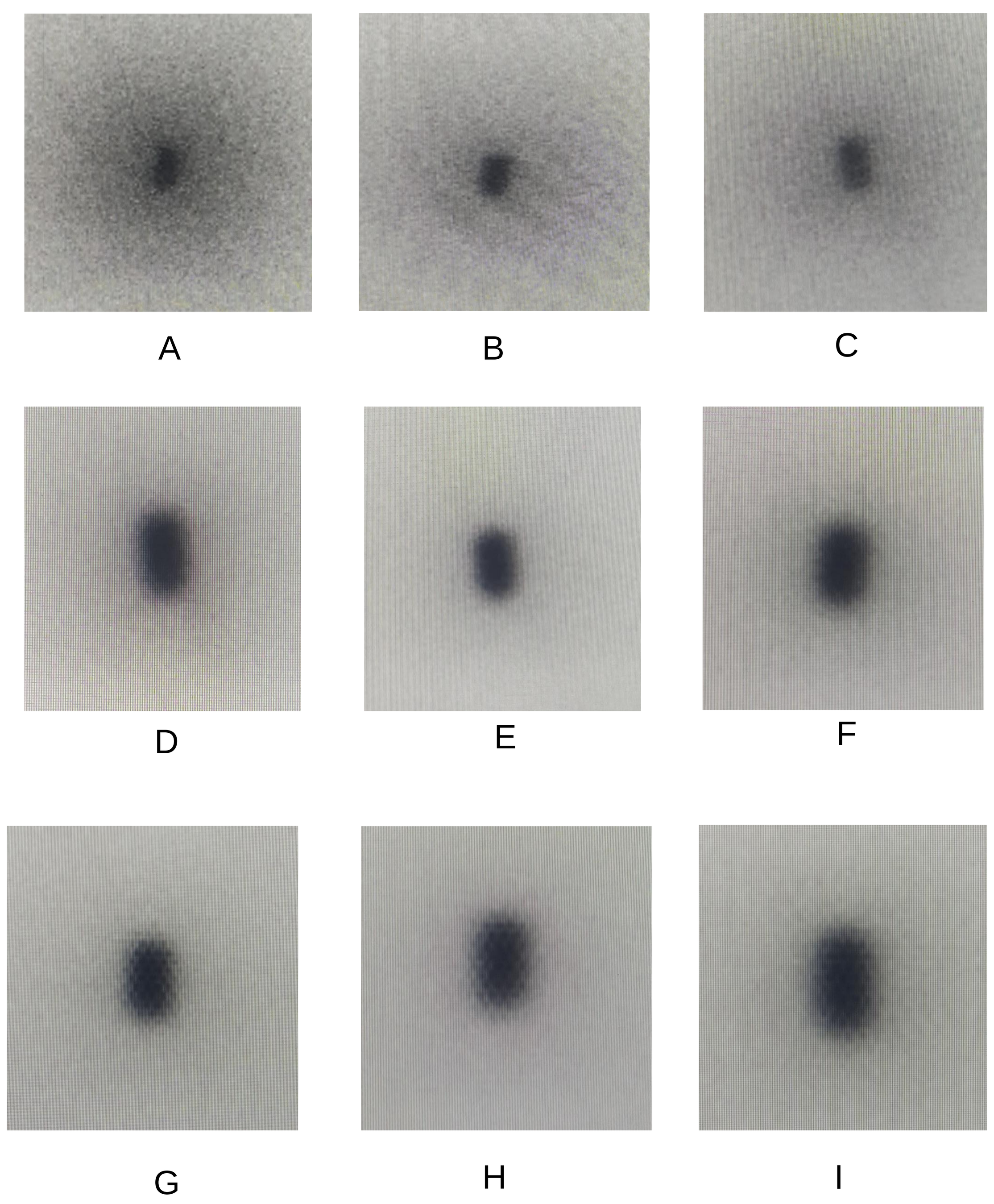


Figure 2. Images acquired for protocol A to I

Discussion

HEGP (H,J) has the highest SBR followed by MEGP (E,F,D) and LEHR (B,C). The higher the SBR, the more spatial information in the images. From the results obtained MEGP and HEGP offer a decent SBR compared to LEHR.

CV is known as ratio of standard deviation to mean. The lower the CV, the lower the variation, the better the estimate. LEHR (A,B,C) has the lowest CV followed by MEGP (D,F,E) and HEGP (G,H). However, CV for all imaging conditions are less than 0.5 which is reasonable.

Furthermore, two energy windows (E,H) always has highest SBR followed by three energy windows (C,F,I) and one energy windows (G,D).

In term of image quality, MEGP with 2 or 3 energy windows (E and F) have the images with best spatial resolution compared to septa effect in HEGP images and grainy images with poor resolution in LEHR images.

Conclusions

MEGP collimator with 2 energy windows (E) gave good results in term of good spatial resolution and moderate SBR and CV.

This proposed imaging protocol can readily to be used to tailor Y-90 planar imaging and SPECT/CT acquisition by applying attenuation correction (AC), scatter correction (SC) and reconstruction protocols for improved Y-90 imaging in our hospital.

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