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Determination of spatial resolution using TC^{99M} on Spect with distance detector variations

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ABSTRACT

It is very important to pay attention to the spatial resolution of the SPECT tool regularly every week to ensure the SPECT plane works optimally so that it can produce more accurate image quality. Using the MATLAB program can help to determine the FWHM value and spatial resolution. In the MATLAB program to calculate the value of FWHM using the ESF and PSF methods, the FWHM values obtained the value of spatial resolution. In this research, several detector distances are used to obtain the best spatial resolution values. the spatial resolution obtained is 0.01 lp/mm-0.04 lp/mm with different distances. The most optimum value is obtained at a distance of 20cm from the detector with a spatial resolution value of 0.04 lp/mm. Quality Control of spatial resolution of images through FWHM calculations can be calculated using the ESF and PSF methods in the Matlab program.

Keywords: Resolution spatial, FWHM, ESF and PSF Methods.

INTRODUCTION

Nuclear medicine is a specialization in medicine that uses open radiation sources to assess the function of an organ, diagnose and treat diseases [1]. In the medical world, nuclear medicine, which aims to obtain information on physiological functions and radiopharmaceutical distribution in an organ [2]. Iimaging modalities are a common thing to talk about. This is due to the importance of imaging modalities to determine organ images or even the condition of an organ without surgery [3].

One of the nuclear medicine imaging modalities that is often used is SPECT (single photon emission computed tomography). SPECT imaging from various angles recorded SPECT imaging is better than gamma camera imaging because it displays images in three directions, where the camera detects the distribution of injected radiopharmaceuticals from various angles around the patient's body at fixed intervals that provide results of organ images in real time, which then can be used to determine the activity of radiopharmaceuticals, the percentage of uptake of radiopharmaceuticals in organs, and organ function [4]. Important acquisitions in imaging are areas between spatial resolution and sensitivity [5].

The spatial resolution of gamma cameras is defined as the ability of the gamma camera system as a whole to determine the original location of gamma rays on an X-Y plane, without spreading a medium defined as the minimum distance between two points in an image that can be detected by the system [6]. In gamma cameras, changes in spatial resolution can be attributed to the efficiency and

linearity of photomultiplier and collimator tubes. Therefore, spatial resolution of gamma cameras must be monitored every week to ensure optimal conditions and performance [7]. Spatial resolution can be known by the value of Full Width at Half Maxsimum (FWHM) which is the width of the graph of the intensity of the position of the distribution function. In determining FWHM it can be helped by Modulation Transfer Function (MTF), Edge Spread Function (ESF), Line Spread Function (LSF) and Point Spread Function (PSF) [8]. Basically the method of MTF, ESF, LSF and PSF can be used all in the method of measuring spatial resolution of the image.

Using the MATLAB program can help to determine the FWHM value and spatial resolution. MATLAB is a programming language commonly used in medical imaging. Can read various image formats. The MATLAB program is often used in spatial resolution analysis on radiological modalities such as CT [9]. Based on the AAPM report no.9 section 6.3 [10] the source is placed 10 cm from the distance of the collimator. Like Parimalah's research, Velo et al. Conducted a study to determine the spatial resolution of gamma cameras using line sources using the MATLAB program. In this study using a gamma source, radifarmaca Tc-99m, which was injected into the syringe butterfly with 5 mCi activity at a distance of 10 cm detector. The results obtained are compared to standard programs. Spatial resolution using MATLAB is 1.24% lower than using standard programs. So this study was conducted to determine the spatial resolution with variations in distance detector using a radiation source, namely Tc-99m. This research was conducted to obtain the optimum spatial resolution value at a certain distance.

METHODS

Image acquisition

The gamma camera used is the Philips BrightView X and XCT detector and Type Dual Head Spect and whole Digital Body Gamma Camera. Radioactive Tc^{99m} is injected using a syringe of 5 mCi to phantom acrylic. Acrylic phantom is used as a substitute for human samples. Acrylic phantoms that have been injected with radioactive Tc^{99m} are placed in the table and given a distance between the ISO center and the detector. acrylic phantom used was 50 mm in diameter. Distance variations used are 20 cm, 40 cm and 60 cm. by using low-energy, high-resolution collimator and 256 x 256 matrix. The number of images obtained is 3 images based on the distance that is varied.

Image process

There is also the first stage by displaying a scan image, which the scan image file is changed from DCOM to the Imagej application into a TIF file, so that it is fossilized in the FWHM calculation process. Then the file is entered into the MATLAB program to calculate the FWHM value using the ESF method. The ESF method is an edge distribution function that indirectly also provides values for point distribution functions (PSF) [11]. To get the function of the edge distribution, ROI crooping is done at the edge area. Then the value of the function of the ESF is obtained, the value of the ESF is differentiated to obtain the PSF value to get the FWHM value.

In the spatial domain, the spatial resolution of this imaging system is characterized by a point distribution function (PSF). The ESF value is derived so that the PSF value is obtained as the FWHM value. The FWHM value shows the sharpness of an image. The smaller the size of the FWHM value, the sharper the value of spatial resolution. So that from the FWHM value we get a spatial resolution value (equation 3.2). To state the magnitude of the spatial resolution (RS) with units of lp / mm or lp / cm obtained from the FWHM value can use the following equation [12].

$$RS = \frac{1}{FWHM} \quad (3.1)$$

In this study carried out at several distances, so to get an optimization value by getting the value of spatial resolution from a distance of 20cm, 40cm and 60 cm. By getting a value from each distance that gets the highest spatial resolution value.

RESULTS

By using the SOP for the Tyroid check, the closest distance from the dector is obtained. SOP on the nearest thyroid is at a distance of 20 cm. So that in this study using a distance of 20cm. but in

this study not only using one distance but with variations in distance. By giving a variation of the distance to the detector, you can compare the spatial resolution. In this study using distance variations namely 20cm, 40cm and 60 cm. At each distance and angle scanning for 5 minutes. After scanning the image format, SPECT is a 16-bit DICOM image with DICOM format. DICOM imagery is a good image because it has complete information from the image in another format even though the data size is larger (500-600 KB).

In this study distance variations were carried out to determine the comparison of FWHM values and spatial resolution values. Variation in distance used is 15 cm, 20 cm, and 25 cm. at each distance the Gaussian function will be obtained from the ESF and PSF method images to get the FWHM value. The Gaussian function at each point can be shown in table 1.

Table 1. FWHM values from each distance

Distances (cm)	FWHM (mm)
20	35
40	47
60	110

In table 1 is a Gaussian function for the image with the same activity treatment that is 5 mCi. Of the three image results indicate that the data obtained has a FWHM value from each distance. At a distance of 20 cm has a value of 35 mm FWHM, at a distance of 40 cm by 47 mm while the 60 cm mark has a FWHM value of 110 mm. from these data it can be concluded that the greater the distance of the detector from the ISO center, the greater the value of FWHM. but on the NEMA (National Electrical Manufacturers Associate Spectification) standard which shows that the FWHM value should be between 7mm and 12mm. in the study the value of FWHM obtained was far higher than the standardized FEMHM value of NEMA. So that this FWHM value can affect the value of Spatial Resolution to be calculated.

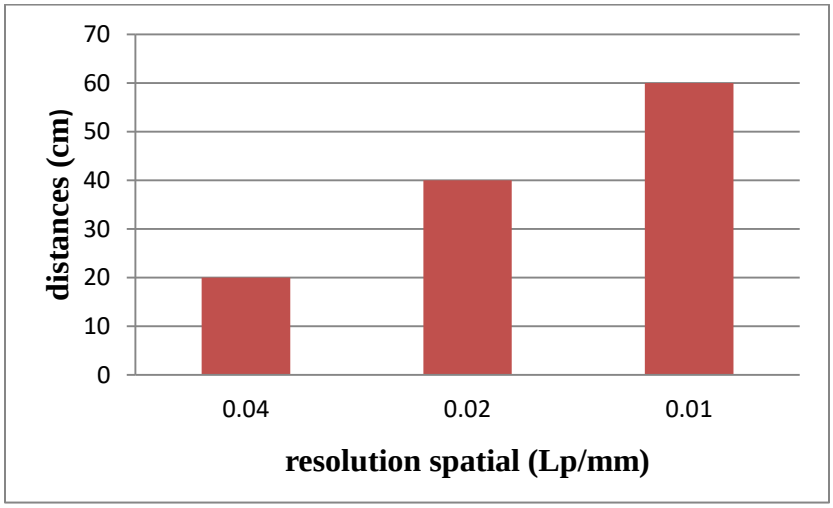

Figure 1. Graph of spatial resolution values with various distances

Spatial resolution values are obtained by knowing the value of FWHM. From Figure 1 the value of spatial resolution is obtained. From Figure 1 shows that the value of spatial resolution with increasing distance, the value of spatial resolution is getting smaller. Different from the FWHM value obtained. For a distance of 20cm the spatial resolution value is 0.04 lp / mm, the distance of 40cm is 0.02 lp / mm and at a distance of 60cm the spatial resolution is 0.01 lp / mm.

The value of the spatial resolution of the image is a representation of the good or not the image produced. In this study the values of the spatial resolution obtained were 0.01 lp / mm-0.04 lp / mm

with different distances. The most optimum value is obtained at a distance of 20cm from the detector with a spatial resolution value of 0.04 lp / mm.

But in this study the value of the spatial resolution obtained was very low. pixel size must be at least 2.5 pixels / FWHM to achieve a systemic error of less than 5%. At least there are 10000 pixel counts in LSF. Rougher digitalization will cause a significant error (AAPM report no. 9). This may be due to the absence of routine spatial re-testing tests every week to evaluate the intrinsic spatial resolution of the SPECT aircraft. So that from this research data can be known for Quality Control of SPECT Aircraft.

CONCLUSIONS

The conclusion of this study is that it can be concluded that the optimum spatial resolution value on the SPECT tool with the ESF and PSF methods in the Matlab program is at a distance of 20cm is 0.04 lp / mm. Quality Control of spatial resolution of images through FWHM calculations can be calculated using the ESF and PSF methods in the Matlab program. As well as being obliged to do a spatial resolution of SPECT devices routinely every week to ensure the SPECT plane works optimally so that it can improve medical services and control the quality of the images produced.

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