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FACTORS AFFECTING THE IMAGE RESOLUTION AND DETECTION EFFICIENCY OF GAMMA CAMERA

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ABSTRACT:

The need for high performance of organ or tissues images pushed many scientists to study the factors affecting the image resolution. Too many factors such as distance, number of counts, and type of collimator were studied in this paper. Count loss depends on the whole energy spectrum; the apparent dead-time depends on the window fraction. Scatter causes narrower of the window fraction then longer dead-time. Resolution is the most talked about digital camera characteristic and is often used to describe image quality. Diverging, converging and pinhole collimators are useful for the change of field view but the image distortion caused by the magnification with depth is a problem.

Keywords: Gamma camera, collimators, resolution, detection efficiency.

Introduction

Imaging by the use of gamma camera, can be considered as radionuclide imaging, which is one of the most important applications of radioactivity in nuclear medicine with the purpose to obtain a picture of the distribution of radioactively substance within the body after administration of radionuclide isotope which emits gamma radiation with energy range from 80 to 500 keV or annihilation phenomenon of photons with energy of 511 keV to the patient. Dense scintillators with good detection efficiency for gamma can stop these penetrating gamma radiations. The major components of gamma camera are: collimator (consists of a lead plate containing a large number of holes), NaI(T1) scintillation detector with large-area, , an array of PM tube, and light guide. The collimator forms a projected image of the gamma ray distribution on the surface of the detector crystal. The detector in Anger camera is NaI(Tl) crystal with large area (0.6 to 1.25 cm thick x 25 to 50 cm in diameter), and thinner crystal in order to get better intrinsic resolution, surrounded with highly reflective material to maximize light output, and optical coupling materials placed between the NaI(Tl) crystal and the array of photomultiplier tubes arranged in hexagonal pattern, part of the signal processing circuitry is attached to each PM tube and sealed in a light-tight protective housing [1]. (Cherry, Sorenson, & Phelps, 2012).

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Figure 1: Gamma Camera at HUSM

Detection Efficiency

Geometric efficiency defined as fraction of gamma rays detected which transmitted by collimator divided by total number of gamma rays emitted with the assumption that attenuation in body ignored. It depends on the distance from the source to the collimator. With a distant point source acting as a flood source with an attenuating medium of air, the absolute efficiency of detectors was about 6% for the energy window specified. The absolute efficiency is the fraction of incident gamma rays (with energy 140.5 ke V) that enter a detector and result in a count being recorded for the specified energy window. Note that this efficiency does not include the collimator's effect on the overall efficiency of the probe. The crystal thickness of NaI(Tl) in Anger camera is smaller than that of a well counter. The small signal and small collimator efficiency cause the gamma camera to be a poor detector for small tumours that are located deep inside the body because of the effect of Poisson noise which is also called counting statistics can make tumours hard to detect, although in most cases Poisson noise is not the major noise. The other factor affects is that the radiotracer is in fact spread throughout normal tissue in a nonuniform manner. The spatial variations make detection due to the variation in uptake in normal tissue instead of being due to a tumour. The resolution of a radioisotope imaging device is a measure of the accuracy with which it can delineate regions with different isotope concentrations. Brownell has proposed a definition for resolution as the distance apart of two point sources which gives image circles on the detecting crystal. A more practical definition put forward by Mallard and Myers equates resolution with the distance apart of two point sources which gives touching image circles on the display. This approach includes any distortions introduced by the analog circuitry forming the display and relies on a subjective assessment [3] (Mallard J.R, 1963).

EXPERIMENT

The Contrast of the Image depends on

1- Distance

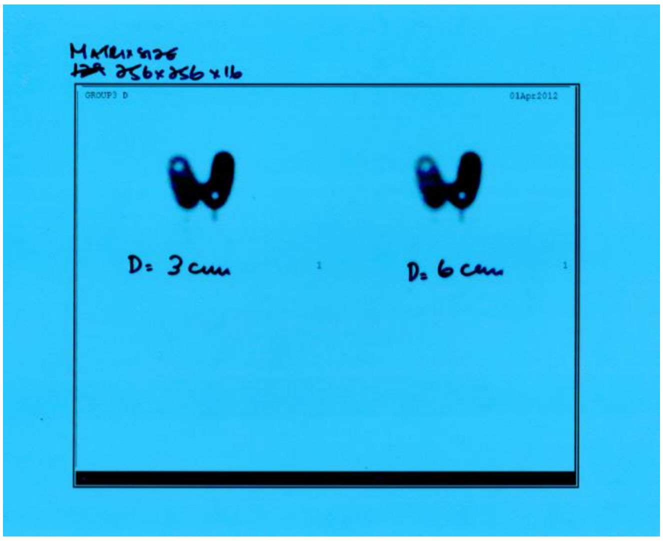

Figure 2: The Image of thyroid gland from different distances

As we can notice here that the more resolution occurs in the left one because its distance is less than the other one. The attenuation of the radiation is proportional inversely with the square distance between the source and the detector as the inverse square law explained. Spatial resolution decreases rapidly at increasing distances from the camera face. This limits the spatial accuracy of the computer image: it is a fuzzy image made up of many dots of detected but not precisely located scintillation

2- Number of Counts

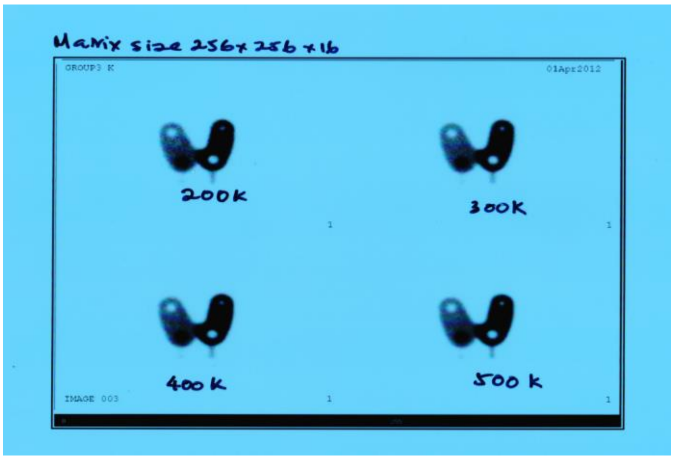

Figure 3: Image for thyroid gland for different accounts.

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When we let the counter to take its time in collecting counts from the source, the resolution will be better but the problem will occur with some artifacts that affect the result, the patient motion.

3- Type of Collimator

Figure 4:Image for thyroid gland for different collimator.

The fact that we used a source with low activity and energy made us to use a collimator with low energy high resolution which suitable for our radioactive source, but because we changed the collimator to another type which affected the resolution for the image as shown in the film taken.

Conclusion

Pulse pile-up is the problem at high-count rate and it results in count loss and image distortion. Two scattered event may be added to form a photo-peak, which produces a location between the two scattered events. Spatial resolution of a parallel collimator increases as the distance between the collimator and the source increased. Collimator efficiency for a source in air is independent of source- collimator distance. Invariance of collimator efficiency with source to collimator distance applies to point sources, line sources and uniform sheet source in air with parallel hole collimators. The fundamental lack of accurate information surrounding resolution makes it one of the most misunderstood discussion topics. Resolution always is best with the source as close as possible to the collimator. For point source in air, the efficiency increases as the source to collimator distance increase with converging collimator and decreases for diverging and pinhole collimators.

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