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A Relationship Between Sampling Error And Signal To Noise Ratio In Gated SPECT

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Abstract

Gated SPECT provides temporal resolution at the expense of a deteriorating SNR. While the level of noise in an image data set is thought to be complex due to the filtering process, this article provides a simple method for determining the trade-off in SNR when altering acquisition parameters.

INTRODUCTION

Gated single photon emission computed tomography (SPECT) provides temporal resolution at the expense of a deteriorating signal to noise ratio (SNR) (1). A potential weakness of gated SPECT is the possibility of insufficient count density per individual frame interval despite the relatively high ^{99m}Tc activity (2). Each projection set will be reduced in counts by a factor equal to the number of collected frames (plus any rejected beats) (3). SPECT image quality is adversely affected by noise which is more problematic in low count gated SPECT. Smaller numbers of counts result in larger statistical uncertainties, or noise (4). Radioactivity counting error (random error) is characterised by Poisson statistics (4) which assumes pixels are independent of one another (e.g. planar images and SPECT raw data) and, thus, does not hold for reconstructed SPECT data where reconstructed pixels are not independent.

DISCUSSION

The level of noise in an image data set, or SNR, is not as intuitive as it might seem due to the filtering process (5). The reconstructed SNR for data reconstructed using a ramp filter can be determined with the following equation:

Figure 1

$$SNR = \frac{\sqrt{N_R}}{\sqrt[4]{R}}$$

where N_R is the reconstructed counts per pixel and R is the number of pixels (resolution elements) containing activity (5). Thus, using an eight interval gated SPECT, a 64 x 64 matrix, a ramp filter and assuming no beat rejections, the reconstructed SNR will deteriorate by a factor of 2.83 for gated data (over the ungated data).

Sampling error is proportional to the inverse of the square root of the sample size:

Figure 2

$$\text{Sampling error} \propto \frac{1}{\sqrt{N}}$$

When N is reduced by a factor of eight as seen in the total number of events per image in gated SPECT, there is a corresponding increase by a factor of 2.83 in sampling error.

CONCLUSION

It is clear that using an eight interval gate increases sampling error and decreases SNR by a factor of 2.83. Furthermore, 2.83 is the square root of eight, thus, we can more simply determine the trade-off in image quality (SNR) and statistical certainty for any number of gate intervals (e.g. using a 16 interval gate would deteriorate SNR and sampling error by a factor of four).

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