Analysis of Image Quality and Optimized Reconstruction Window through Heart Rate and Its Variation in Retrospectively ECG-gated Coronary Angiography Using Multi-Detector Row CT

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ABSTRACT

Image quality and selection of optimized window for good quality reconstruction in coronary angiography using multi-detector row CT (MDCT) have not been studied by heart rate and its variation. Therefore, the effect of heart rate and its variation was systemically analyzed. Eighty-three patients were undergone contrast-enhanced coronary angiography using MDCT. In this study, sixty cases were enrolled. Two radiologists graded image quality as follows: 4, excellent; 3, good; 2, fair; 1, bad. The starting points of the reconstruction window were chosen at seventy and forty percent of R wave interval. Optimized window was scored as 1 when 40% reconstruction was better quality than 70%, as 2 when 40% reconstruction is same as 70%, and as 3 when 70% reconstruction was better than 40%. Regression analysis was performed. The range of variation of beats per minute (BPM) was well correlated with image quality (r=-0.55, p=0.000), however correlation with optimized window percentage was not statistically significant (p=0.969). By contraries, median value of BPM was comparatively well correlated with optimized window grade (r=-0.24, p=0.086). Median value of BPM was not well correlated with image quality (r=0.170, p=0.197). Image quality is more affected by variation of heart rate (VHR) than by higher heart rate. Selection of optimized reconstruction window for good image quality is mainly affected by heart rate and there is a tendency that systolic phase reconstruction is better in image quality than diastolic reconstruction in higher heart rate.

Keywords: multi-detector row CT (MDCT), electrocardiography (ECG), coronary angiography, variation of heart rate (VHR), optimized reconstruction window

1. INTRODUCTION

Recently it has been proved that image quality is highly dependent on the heart rate and advised to evaluate to lower heart rate to <65 beats per minutes (BPM) in order to achieve best image quality (1). In addition, it has been reported that the image reconstruction window for CT angiography of the coronary arteries should be adapted to each coronary artery (2). However, the effect of heart rate and its variation about image quality has not still been studied. When imaging is performed at only one time point in cardiac cycle, the outcomes can be optimal for only one three major coronary arteries. Cardiac cycle can be changed continually as a patient's condition in one breath hold time and, as heart rate is faster and its variation increases, it would be more difference between image acquisition time and minimum cardiac motion time. Therefore, the purpose of the present study was to evaluate the influence of heart rate and its variation on image quality and optimized window for good quality reconstruction in coronary angiography using multi-detector row CT (MDCT).

2. MATERIALS AND METHODS

We performed contrast-enhanced coronary angiography using MDCT (LightSpeed XQ/I, GE medical systems, Milwaukee, WI) in 83 patients. Sixty cases with available information of heart rate were enrolled in this study. Time resolution was 250 milliseconds and multi-sector reconstruction algorithm was not available (ie, scanning data from only one heart cycle were used to reconstruct an image). Variation of heart rate was recorded from 2 to 65 (VHR, mean 12.7±10.9). Median value of beats per minute (BPM, range 50-100) was recorded.

Image quality was graded by two radiologists as excellent (grade 4, n=17) when all proximal to mid coronary arteries were assessable, good (grade 3, n=21) when two proximal to mid coronary arteries were assessable, fair (grade 2, n=11) when all proximal coronary arteries were assessable, and bad (grade 1, n=11) when only one or two proximal coronary

arteries were assessable.

Seventy and forty percent of R wave interval were routinely selected for image reconstruction window, which represent systolic and diastolic phase. It was for reason that the optimal delay is at 40% of R-R interval for the right coronary artery and 70% R-R for the left coronary artery (2). Optimized window was graded as 1 when 40% reconstruction was better quality than 70%, as 2 when 40% reconstruction is same as 70%, and as 3 when 70% reconstruction was better than 40%.

Regression analysis was performed. A P value <0.05 was considered statistically significant. The comparison was performed between heart rate and VHR for acquisition images. We analyzed respectively the correlation of VHR and optimized window percentage; median value of BPM and optimized window grade; and median value of BPM and image quality. The overall results in terms of image quality were compared for the left anterior descending artery, left circumflex artery and right coronary artery.

3. RESULTS

The range of variation of BPM was well correlated with image quality (r=-0.55, p=0.000), which means image quality decreased with wider variation of BPM, however correlation with optimized window percentage was not statistically significant (p=0.969). By contraries, median value of BPM and optimized window grade was relatively well correlated (r=-0.24, p=0.086), which means that 40% reconstruction is better in image quality than 70% reconstruction in higher heart rate. Median value of BPM was not well correlated with image quality (r=0.170, p=0.197).

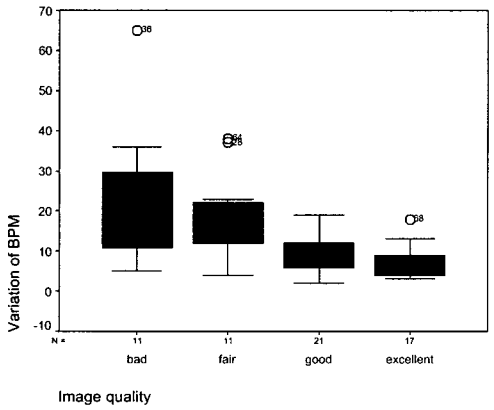


Fig 1. Box plot representing the relation between image quality and variation of BPM. Image quality is better in lower variation of BPM.

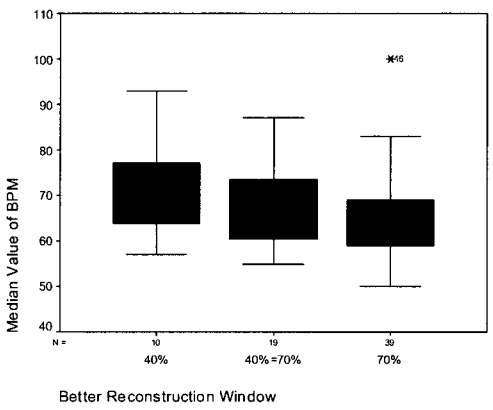
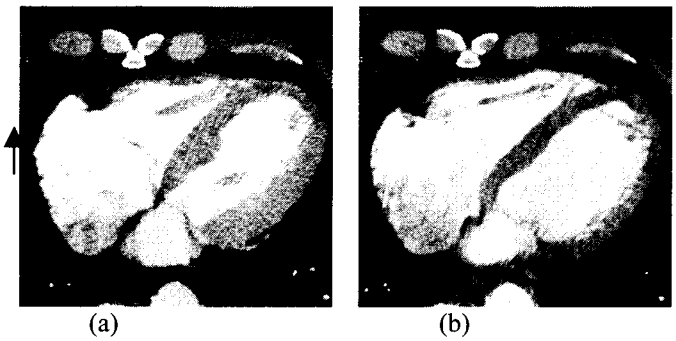
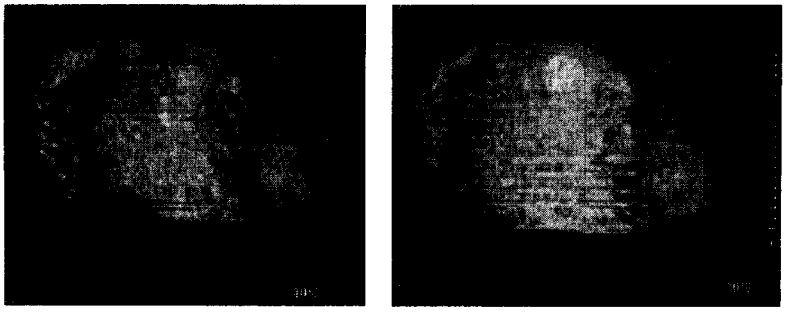


Fig 2. Box plot representing the relation between Optimized window and heart rate. Reconstruction in 40% phase is better quality than 70% in higher heart rate.



(a) (b)

Fig 3. Comparison of 40% (a) and 70% (b) reconstructed images in a patient with median heart rate of 64 BPM and variation of 18 that was graded as bad. Right coronary artery (arrow) is well visualized only in 40% image.



(a) (b)

Fig 4. Comparison of 40% (a) and 70% (b) reconstructed images in 3-dimensional images in a patient with median heart rate of 70 BPM. 40% reconstruction image shows fewer artifacts than 70%.

4. DISCUSSION

Higher heart rate and VHR cause much degradation of image quality. Higher heart rate occurs, the more minimum cardiac motion time decreases. Therefore image quality is degraded by more difference between image acquisition time and minimum cardiac motion time in higher heart rate. On the other hand, wider VHR causes ECG abnormalities that may prevent appropriate trigger selection. The results of our study have demonstrated that image quality is more affected by VHR than by higher heart rate. Moreover, whereas heart rate acceleration increases the systolic component of the cardiac cycle relative to diastole, a decrease in heart rate reduces it, particularly a decreases to fewer than 75 BPM (4). Consequently we found that selection of optimized reconstruction window for good image quality is mainly affected by heart rate and there is a tendency that systolic phase reconstruction is better in image quality than diastolic reconstruction in higher heart rate.

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