Initial Evaluation of Coronary CT Angiography Image Quality on the Revolution CT System

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INITIAL EVALUATION OF CORONARY CT ANGIOGRAPHY IMAGE QUALITY ON THE REVOLUTION CT SYSTEM

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INTRODUCTION

- BACKGROUND: CT Perfusion allows for the evaluation of myocardium in particular for the detection of ischemia and infarction. Previous studies have, however, described beam hardening artifacts within the myocardium, which may have an effect on identifying true perfusion defects. Larger or voxel-based coronary CT scanners have shown promise in reducing myocardial heterogeneity but have been limited by cone beam artifacts and lower gantry rotation speeds. We sought to evaluate the performance of a new volumetric CT scanner (Revolution CT, GE Healthcare) enabled with novel wide cone reconstruction software (Volume HD reconstruction) and improved temporal resolution with regards to image quality and signal homogeneity.

METHODS

- DESIGN AND SETTING: Study Groups: Prospective enrollment of 24 subjects was performed from May 2013 to November 2013. This study was approved by IRB. All 24 patients provided informed consent. Inclusion criteria were: 18 years or older not requiring acute care, without allergies to iodinated contrast media, and without renal insufficiency. Women less than 60 years of age were confirmed to be non-pregnant.

- All 24 patients had both a volumetric CTA study (Revolution CT scanner) for research purposes after having undergone a prior clinical 64-slice CTA (64-Slice CT scanner). The 64-slice CTA scan may have been performed at a prior time point within a few weeks or months. This made for an in-person comparison of 24 subjects which formed our analysis.

- CTA SCAN PROTOCOLS AND IMAGE RECONSTRUCTION:
  - The CT images from the larger detector scanner were acquired in one heart cycle with a volumetric coverage of 16 cm (256 slice CT x 0.625mm) (Revolution CT, GE Healthcare) and a gantry rotation speed of 0.28 sec/revolution. Images were reconstructed with Volume HD reconstruction and next generation iterative reconstruction technology. (ASIR-V Adaptive Statistical Iterative Reconstruction, GE Healthcare, Milwaukie, WI) Table 1. Compared to past generations of iterative reconstruction, the version being validated in our analysis includes more advanced image noise and object modeling.

- All CT acquisitions with the Volumetric CT scan were axial prospectively triggered CTA with different acquisition windows dependent heart rate. Motion correction software (SnapShot Freeze, GE Healthcare) was selectively applied only if motion was present.

- Patients were given an injection of 60 cc of contrast in the first phase, followed by 20 cc of contrast and 30 cc of saline in the second phase and completed by 50 cc of saline. Effective radiation dose was calculated by multiplying dose-length product with the conversion factor for Cardiac CT examinations (0.034 mSv/Cm-Gy). TABLE 1

- STATISTICAL ANALYSIS (SIGNAL, INTENSITY, NOISE AND CONTRAST):
  - The post-processing analyses were performed on an offline three-dimensional workstation. Multiplanar reconstructions of the left ventricular chamber at 5 mm thickness were created. Quantitative measures of image quality were performed in the myocardium, blood pool and aorta. Six Region of Interest (ROI) measurements were made across the myocardium in each of the Volume CT image sets as well as in the 64-slice CT image sets (Figure 1).

- An ROI of the myocardial wall was obtained, which ranged between 0.1cm2 and 0.2cm2. These measurements were made in the following regions: base-anterior, base-inferior, mid-anterior, mid-inferior, apex-anterior, apex-inferior. The same technique was used to assess myocardial blood pool ROI measurements made in the left ventricular chamber at the base, mid and apex of the heart in each of the Volume CT as well as the 64-slice CT image sets.

- Unlike the smaller ROI in the myocardial wall, a larger maximum ROI ranging between 1cm2 and 4cm2 was utilized to assess the most possible blood pool. ROI measurements ranging between 1cm2 and 2cm2 were made in the aorta in each of the Volume CT image sets as well as the 64-slice CT image sets.

- These measurements were obtained in one session by a single radiologist (RR, 3 years of post-fellowship experience) manually placing a circular region of interest at each anatomic site mentioned above. Signal-to-noise ratio (SNR) was calculated by dividing the mean CT number within the ROI divided by the standard deviation from the mean value within the ROI.

- The variation in mean values across multiple ROI was quantified by the Coefficient of Variation (CV). This value is calculated by dividing the standard deviation of the mean CT numbers across multiple ROI measurements by the mean CT number. The CV metric normalizes relative contrast volume and specification differences from patient to patient, which do not reflect the performance of the scanner itself.

- RESULTS:

- Heart Rate: The median heart rate of patients undergoing the Volume CT was 60 bpm ± 10 SD (range=49-86).

- The median heart rate for patients undergoing 64-Slice CT was 77 bpm ± 6 SD (range=64-84). A significant difference was found in heart rate between the Volume and 64-slice CCTA (p=0.036). Motion correction was applied at the time of the scan acquisition in 11 of 24 subjects. Radiation Dose: Median effective dose for the Volume CT studies was 2.06 mSv ± 0.87 (median=2.97). Median dose for the 64-Slice CT images was 3.79 mSv ± 5.76.

- On the 8 slice platform, 8 patients had retrospectively gated scans and 16 had prospectively triggered CTA. For the retrospectively gated CTA was 4.74 ± 1.28. As expected, there was a significant difference in the radiation dose between those who had retrospectively gated scans from prospectively triggered CTA (p=0.002).

- Quantitative Analysis: The differences between the CV in the 64-slice and Volumetric CTA were significantly different in each of the myocardium (p=0.007), base to mid (p=0.007), mid to apex (p=0.007).

- Measurements of SNR and Image Quality: Signal Intensity, Noise and SNR were tested between the Volume and 64-slice CT image sets.

- A two-sided t-test was applied when the distribution of data from the Volume and 64-slice CT image sets were of equal variance, and Welch's t-test was used when unequal variance was found.

- CONCLUSIONS:

- CT Perfusion allows for the evaluation of myocardium in particular for the detection of ischemia and infarction. Previous studies have, however, described beam hardening artifacts within the myocardium, which may have an effect on identifying true perfusion defects. Larger or voxel-based coronary CT scanners have shown promise in reducing myocardial heterogeneity but have been limited by cone beam artifacts and lower gantry rotation speeds. We sought to evaluate the performance of a new volumetric CT scanner (Revolution CT, GE Healthcare) enabled with novel wide cone reconstruction software (Volume HD reconstruction) and improved temporal resolution with regards to image quality and signal homogeneity.