A Simple Noncontrast FBI Technique for Peripheral Run-Offs: Development of Automatic Algorithm to Find Systolic and Diastolic Triggering Delays

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PURPOSE:

Noncontrast peripheral MRA examination using ECG-gated 3D half-Fourier FSE (Fresh Blood Imaging: FBI (1,2)) takes about 25-45 min. to cover three (aortoiliac, femoral, and popliteal) stations. The examination consists of locator imaging, ECG-prep scan and analysis, and 3D FBI scan for each station. The 3D FBI scan relies on the signal difference between diastole and systole. The diastolic and systolic trigger delays are usually determined by the single-slice, multiple-phase scan (ECG-prep scan) or phase contrast method. Although the examination time for each station of the 3D FBI scan is not long (3 to 3:30 minutes), the ECG-prep scan and its analysis is time consuming, especially for non-experienced operators. This lengthy exam and cumbersome procedure can hinder the use of this noncontrast MRA technique. In order to reduce the scan time and to improve ease of use, we developed a simple algorithm to automatically determine the systolic and diastolic trigger delay times that is required for a successful FBI run-off examination.

MATERIALS and METHODS:

Using the systolic duration (SD) from the heart rate, where SD = 550 msec - 2*Heart Rate (HR) (3), our hypothesis was made under the assumption that a peak systolic flow (systolic trigger delay) is around the mid-point of the systolic duration. The same analogy was applied to calculate the diastolic trigger delay using Diastolic Duration (DD) = RR interval - SD. The auto-ECG algorithm was implemented and installed on the system to automatically calculate the systolic and diastolic trigger delays with detected heart rate. The noncontrast 3D MRA experiments using the proposed auto-ECG algorithm and ECG-prep method were performed on 12 volunteers using a 1.5-T clinical scanner (Toshiba Vantage/Atlas,™ Tokyo, Japan). Typical parameters of 3D half-Fourier FSE scan were TR=2-3RRs, effective TE=78 msec, echo train spacing = 4 msec, parallel imaging factor=2, matrix=256x256, FOV=40x40 cm, NAQ=1, forty 3-mm thick slices (1.5-mm slice thickness after interpolation), and a total scan time of about 3 to 3:30 min per station.

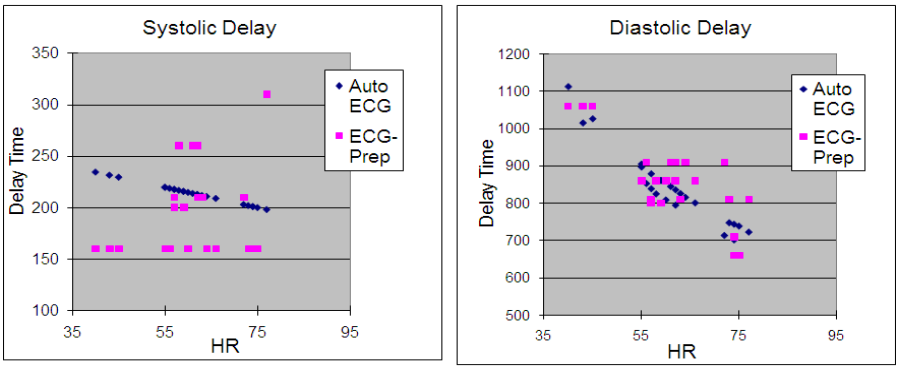

Fig. 1 shows systolic and diastolic trigger delays vs. HR on 12 volunteers.

RESULTS:

All 3D data obtained using the auto-ECG systolic delays resulted in dark blood signals and all of the diastolic trigger delays provided bright blood signal that indicated images were acquired at desired systolic and diastolic phases. After subtraction and MIP processing, high quality MR angiograms were obtained in all volunteers. The image quality of both methods provides very similar image quality, as shown in Fig. 2. Using the auto-ECG algorithm, the three-station FBI examination time is reduced to about 15 to 18 min. In addition, this throughput improvement eliminates additional ECG prep scans and analysis.

CONCLUSION:

The auto-ECG algorithm, automatically calculating the systolic and diastolic trigger delays when detecting the heart rate, was developed and excellent 3D noncontrast peripheral MR angiograms were obtained. Reduction of scan time and easy operation was achieved using the auto-ECG algorithm compared to the ECG-prep method.

Fig. 2: three-station FBI images obtained using the ECG-prep (left) and the auto-ECG (right) methods.

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