2D Accelerated Single Breath Hold 3D First-Pass Sequence for Coronary Artery Imaging using Segmented Elliptic Centric View Ordering

A. Shankaranarayanan[1], A. Carrillo[2], M. Fung[1], G. Reynolds[3], D. Nishimura[4], E. Schmidt[3], and B. Hu[5]

[1]Global Applied Science Lab, GE Healthcare, Bethesda, MD, United States, [2]Global Applied Science Lab, GE Healthcare, Evanston, IL, United States, [3]Global Applied Science Lab, GE Healthcare, Boston, MA, United States, [4]Dept of Electrical Engineering, Stanford University, Palo Alto, CA, United States, [5]Dept of Cardiology, Palo Alto Medical Foundation, Palo Alto, CA, United States

Introduction:

Noninvasive coronary angiography techniques are generally time-consuming given the dual needs for high-resolution and adequate signal to noise ratio. Conventional approaches usually employ either 3D non-breath holding with motion compensation [1] or rapid 2D acquisition with multiple-breath holds [2]. The advantages of a coronary sequence that combine 3D coverage and 2D imaging speed have been hampered by the need for rapid data acquisition and sufficient signal to noise ratio. We describe a 2D-accelerated 3D coronary imaging sequence that encompasses the entire heart in a single breath hold. Coronary conspicuity is further improved by acquiring the data during first-pass contrast enhancement [3].

Methods:

A first-pass 3D gradient echo sequence was implemented on a GE 1.5T Signa TwinSpeed system (GE Healthcare Technologies, Milwaukee, WI) with a high performance gradient system achieving a maximum gradient strength of 40mT/m and maximum slew rate of 150mT/m/msec. An 8-element cardiac array coil was used for acquisition. A non-selective IR Preparation was used with a prescribed inversion time (TI) (175-200ms) for background suppression. Spectral fat saturation pulse was used to suppress the fat layer around coronaries. Elliptic Centric (EC) view ordering was used to achieve the maximum effectiveness of the IR prep pulse. The 3D sequence used the following imaging parameters: 256x192x48 data matrix (after reconstruction), flip = 25°, receiver BW = ±125kHz, TE= 1.9ms and TR = 2.9ms. The achieved spatial resolution was 1.1x1.2x2.3mm. A variable-density self-calibrating scheme was used with an acceleration factor of 2 in the phase direction, an acceleration factor of 1.5 in the slice direction. The sensitivity maps were generated from a 24x20 fully sampled region. The corners of the EC sampling were not acquired resulting in additional time savings. The Generalized Encoding Matrix (GEM) [4] approach was used to reconstruct the data.

Initially experiments were performed on animals to determine the feasibility. Volunteer and patient experiments were also performed after informed consent. The 3D data set was acquired axially with the slice FOV prescribed to obtain complete heart coverage. Typically, 44-50 slices were acquired. An initial 8cc test bolus of gadopentetate dimeglumine was administered with a power injector at a rate of 2 cc/s. Using the timing information derived from the test bolus, contrast was administered for 10sec at the same rate as that of the test bolus. The enhanced coronaries were then reformatted to get the entire length of visible coronary artery.

Results:

Figure 1 shows the reformatted Left Anterior Descending (LAD) artery obtained from the animal. Note the good conspicuity of the vessel. Figure 2 shows the reformatted proximal left coronary artery obtained from a patient with a bypass graft. Note that the background suppression is sufficient to depict the enhanced coronary artery in the foreground. The LM, proximal LAD, Proximal circumflex arteries and the saphenous bypass to the LAD are also seen in this reformat. In general, the timesavings obtained using the 2D accelerated sequence with the described parameters were approximately 30% allowing all the data to be collected in a single breath hold.

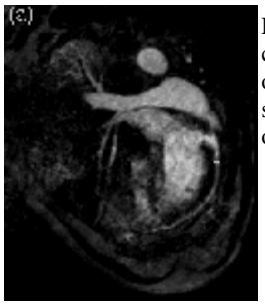

Figure 1: Reformatted right coronary artery of the sheep obtained using the first pass sequence. Note that the full length of LAD is conspicuous.

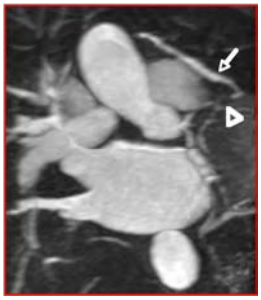

Figure 2: Maximum Intensity Display of the proximal left coronary artery. The LM, proximal LAD, Proximal circumflex arteries and the saphenous bypass to the LAD are seen on this view. Arrow points to the bypass graft. Arrowhead points to an occlusion of the LAD just prior to the insertion of the graft.

Discussion and Conclusion:

This study demonstrates the feasibility of a rapid, high-resolution, contrast-enhanced coronary imaging sequence combing rapid imaging techniques with short TR imaging in the setting of marked T1 shortening during first-pass contrast injection. We expect significant improvements in coil construction, continuous acquisition, and imaging at higher field to bring this type of approach to the clinical arena.

References:

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