Single Breath-Hold Whole-Heart MRA Using Variable Density Spirals and Localized Coil Demodulation

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Introduction: We have previously demonstrated a single breath-hold whole-heart acquisition method using variable density spirals [1]. Taking advantage of the restricted FOV created by the sensitivity profile of a surface coil, controlled undersampling can reduce the acquisition time without introducing coherent aliasing artifacts. One important characteristic of the previously presented method is that it acquires the volumetric data in a multislice fashion with an ultra short acquisition widow (less than 6 ms). This provides great immunity to motion. In this abstract we present an extension using multiple acquisition coils with localized sensitivity demodulation to improve the SNR and volumetric coverage.

Methods: The Nyquist criteria determine the appropriate sampling rate that avoids aliasing artifacts given a constrained FOV. Undersampled variable-density spirals is an acquisition trajectory that can violate the sampling requirements at a benign cost of increased background noise without introducing coherent or structured aliasing artifacts [2]. We have used this method to significantly reduce the acquisition time to accommodate several slice acquisitions in a single R-R interval [1]. This enables to acquire the whole heart in a single breath-hold. A design consideration is to minimize the sensitivity region of the acquisition coil to only contain the object of interest. In cardiac applications it is often necessary to use multiple acquisition coils at different locations to provide uniform coverage of the heart. An important drawback is that the FOV is considerably increased as each coil expands the sensitivity region. If we ignore this increase of FOV severely aliased images may result (Fig. 1-left). It is interesting to observe that each coil independently supports the acquisition FOV. The PILS method [3] accelerates the acquisition by undersampling in the phase encoding direction so the image produced by each independent coil is not aliased. The final image is obtained by combining the resulting sub-images from each coil. In our case that we already achieved acquisition time reduction, we use the localized sensitivity of each coil to increase the supported FOV and SNR at no cost in acquisition time. Ideally independent channel hardware demodulation [4] can be used to center the acquisition FOV on the sensitive region of each coil. As that capability is not provided on current commercial scanners, the FOV cannot be individually localized resulting in loss of information due to the antialiasing filter. Alternatively we can increase the acquisition bandwidth to demodulate the location of each coil at reconstruction time. In our experiment, we designed the acquisition sequence for a 250 KHz bandwidth over a 20 cm FOV and we oversampled at 500 kHz. This expands the area where the individual coils can be placed up to 40 cm. For the final image composition, each sub-image was apodized to minimize the effect of the edges. To demonstrate the proposed method, an 18 interleave, 6 ms spiral sequence was designed for 0.8 mm resolution supporting a FOV that varies from 20 cm at low spatial frequencies to 8 cm at high spatial frequencies.

Results: Phantom studies were done to demonstrate the effectiveness of the method in removing the aliasing artifacts. Additionally the method was tested in vivo on a GE Signa 1.5 T scanner. The imaging sequence originally designed for a single surface coil was used with an 8 channel cardiac phased array. Figure 1-left shows the severe artifacts that result from the aliasing introduced by not supporting the combined FOV. Figure 1-right shows the result of demodulating each coil according to the location of their sensitive region. Observe how the aliasing artifacts are effectively eliminated.

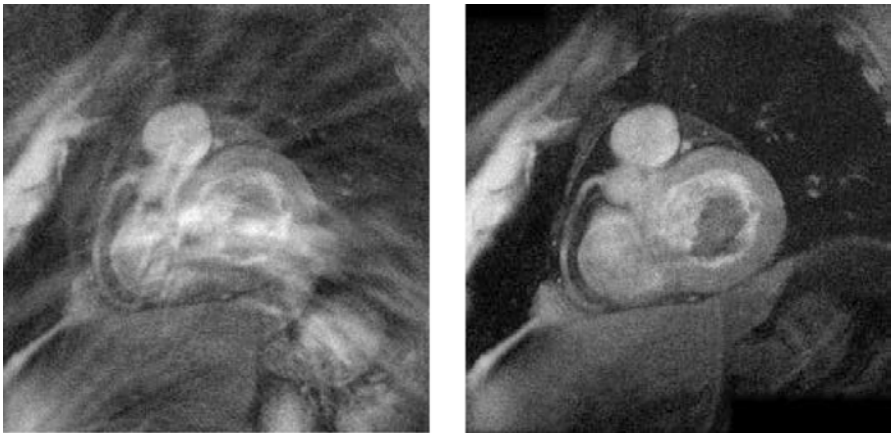

Figure 1: RCA acquired with an 8-channel chest coil using a 20 FOV variable density spiral trajectory. On the left is a standard sum of squares composition. The right image shows the result of demodulating independently each coil.

Conclusion: Coronary imaging remains difficult with the need for higher temporal and spatial resolution, thinner slices, and volumetric coverage. We have developed a single breath-hold whole heart acquisition technique that uses controlled undersampling to speed up the acquisition and local coil sensitivity demodulation to provide uniform coverage of the heart.

References:

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