Rapid Cardiac MRI Using Local Planar Gradients

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Introduction: Spatial and temporal resolution in cardiac MRI are often limited by gradient amplitude and/or slew rate. These limitations can also lengthen TR in balanced steady state free precession (SSFP) pulse sequences, resulting in increased banding artifacts. We describe here cardiac MRI experiments employing local flat gradient coils that can reach 500 mT/m strength at 320 A while keeping temperatures within safe limits (1). Because the gradients are applied over a relatively small imaging volume, local coils have the additional advantage of keeping the maximum dB/dt within safe limits.

Methods: The flat gradient coil set described in (1) was used in cardiac imaging experiments on a 1.5T Signa scanner. Figure 1 shows the conductor patterns for the x, y, and z gradient boards. Each axis was composed of two sets of boards connected in series. Boards were assembled with cooling lines between them, and impregnated with high-temperature epoxy and instrumented with thermocouples. The coil was mounted on a modified bridge inside a GE Signa scanner as shown in Fig. 2 (left). GE HFD gradient amplifiers were tuned to match the flat gradient characteristics.

Balanced SSFP imaging was performed on phantoms to calibrate gradient strength (Fig.2, right) and on normal volunteers. A receiver coil array was placed on the gradients and the subject was positioned prone over the coils. ECG leads were connected to the subject's back. Manual gradient shimming was conducted before scanning, resulting in significantly different shim settings than on the conventional gradients. After imaging, an unwarping algorithm (1) was applied to ameliorate image distortions arising from nonlinearities in the gradient fields.

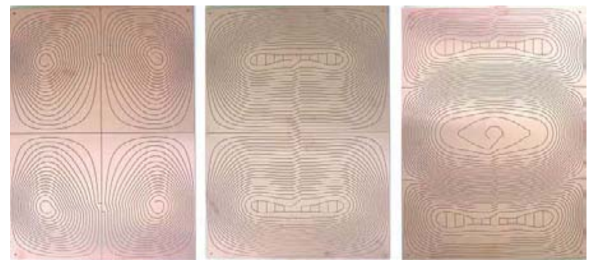

Figure 1. Conductor patterns for (left-to-right) *x*, *y*, and *z* gradient coils.

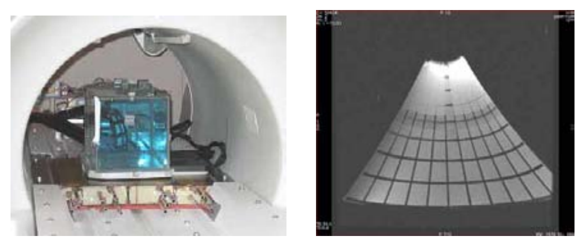

Figure 2. Assembled gradient coils installed in the bore of the scanner (left). Axial image of square grid phantom acquired with gradients (right).

Results and Discussion: The coil was operated without either significant surface temperature increases or movement during MRI. Voltages induced in the ECG leads from the gradient pulses appeared to be much lower in this configuration than with conventional gradients, consistent with the relatively low gradient strengths at the back of a prone subject. Figure 3 shows a series of systolic and diastolic frames from coronal cine data sets acquired at different depths using balanced SSFP (matrix size 256x256, slice 5 mm, TR 2.6 ms), after correction for image distortion. The effective FOV ranges from 20 cm in the shallowest slices (left) to 40 cm in the deepest shown (right), as the gradient strength falls off with depth. By comparison, similar images with the same slice thickness and matrix size acquired using a conventional GE CRM gradient set (40 mT/m, 150 T/m/s) would require a TR of 4.3 ms to achieve an FOV of 24 cm. Alternatively, a TR of 2.6 ms could be achieved on the CRM if the FOV was increased to 48 cm, keeping other imaging parameters constant.

Smaller flat gradient coil systems provide large gains in gradient field strength and slew rate in the anterior heart, enabling significant reduction in FOV and/or TR. This may be useful for cardiac functional imaging at high field strength or for high-resolution coronary imaging in the anterior coronary tree.

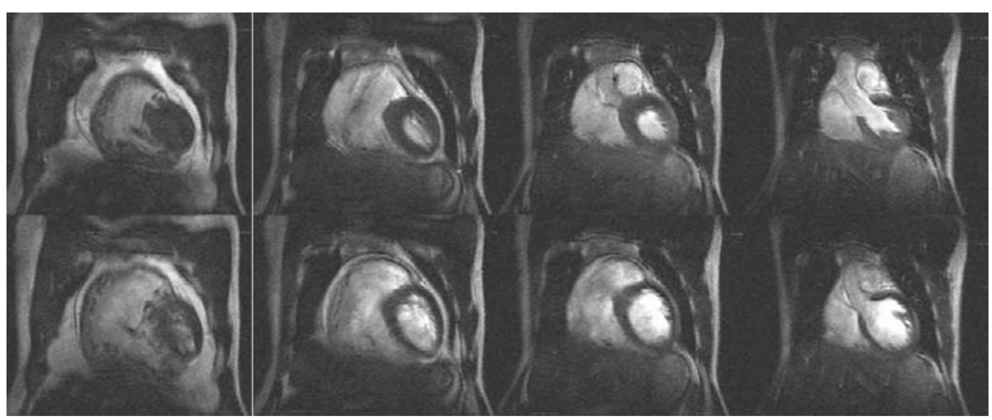

Figure 3. Systolic (top) and diastolic (bottom) frames from coronal balanced-SSFP cine data sets acquired with flat gradients at different depths.

References:

l, B. Aksel, et al. Proc ISMRM 14 (2006), 780.

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