Trans-Esophageal Cardiac MRI: Initial Clinical Experience

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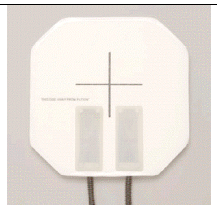
Background: Trans-esophageal echocardiography (TEE) is routinely used to improve field of view and resolution in cardiac ultrasound. With MRI, image quality depends on signal detection efficiency, contrast, field of view, acquisition matrix and acquisition time. For Trans-Esophageal MRI (TEMRI) an antenna wire is placed in the esophagus to enable strong signal reception in its vicinity, and weak signal distally. The strong local signal increases SNR and the weak distal signal enables reduced FOV. The rationale for obtaining this data with an esophageal coil is that, in many clinical situations, the current methods of cardiac evaluation both by standard MRI imaging and echocardiography may not reveal important details needed for clinical decisions. Current MRI technology produces a relatively weak signal to noise ratio that limits the detail of images. Placing a coil in the esophagus provides a stronger signal than otherwise available for structures near the esophagus, which include the heart valves, coronaries and great vessels.

Methods: Figure 1 shows the coil system (Magna-Lab, Inc.). The system consists of a maleable MRI micro receiver coil in a balloon, introduced into the patient's esophagus, positioned directly behind the heart, anchored by balloon inflation, and a small focused surface receiver coil placed over the anterior chest. The esophageal coil contains two perpendicular deformable loop antennas in quadrature, measuring 120 mm x 80mm when the balloon is inflated. With informed consent, subjects received topical anesthesia with cetocaine spray, then swallowed the catheter, which was anchored at the appropriate distance from the mouth by gentle balloon inflation. After inflation, tune and match were performed and images were obtained. Figure 2 shows images obtained with (a) TEMRI compared to (b) body coil. Contrast:noise was calculated for proximal LAD or LCX coronary artery cross sections (wall vs. lumen) by double inversion recovery imaging with TEMRI or with the body coil in corresponding views, in 15 subjects (7 normal volunteers and 8 patients). Effective field of view was calculated as the width of signal in phase-encoding direction with SNR>2. Paired t-test was used for comparisons.



1a: Surface Coil

1b: Esophageal coil

1c: deflated / inflated

Fig. 1 The Illuminator Surface Coil and Esophageal Probe

Results: The TEMRI system provides higher CNR (3.55± 0.64) vs. body coil (2.15±0.98), p<0.0001. The effective FOV was smaller by a factor of 2.31± 0.98, e.g., body coil required 131% more in phase encoding lines for matching resolution. Fig. 2 shows images by each method with same acquisition parameters, and a high resolution image of eccentric plaque in a coronary.

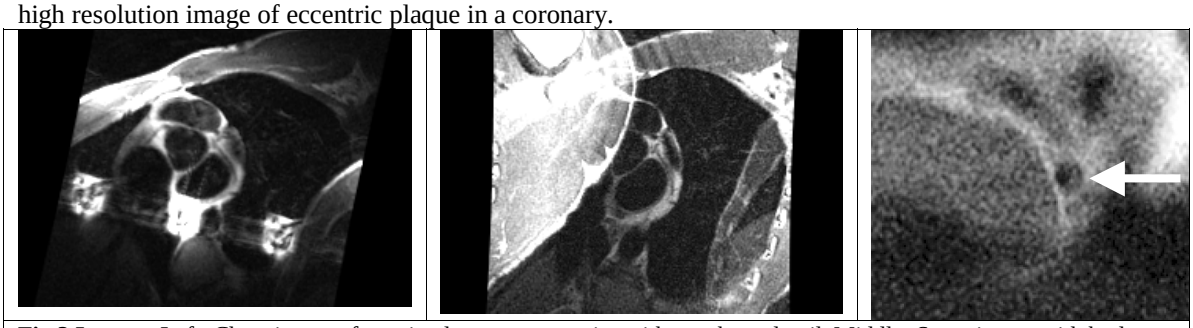


Fig 2 Images. Left: Chest image of proximal coronary arteries with esophageal coil. Middle: Same image with body coil, parameters (TR/TE=1765/44, matrix 256x256, FOV 30 cm. Note severe fold-over artifact with body coil, and weaker signal, c.f. TEMRI. Right: 0.4 mm resolution image of LCX showing eccentric atheroma (arrow), obtained in 18 seconds, no averaging. Use of higher matrix plus signal averaging enables even higher resolutions.

Conclusion: Transesophageal MRI enables small field of view, so imaging can proceed at high resolution with less than half the encoding time for targets near the esophagus. Contrast:noise is significantly improved for targets within 3-4 cm. The reduced number of phase-encoding lines can be converted to over sampling within an equal acquisition time, to improve the gain in contrast:noise further. Field of view of 12 cm was routinely feasible. Targets seen better by TEMRI include the aortic and pulmonary valves and the proximal coronary arteries. Unlike transesophageal echo, the pulmonary valve is routinely seen quite well in its short axis view (in plane) as well as in long axis views.