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Cardiac MR: The New Frontier

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MRI of the human heart, even spin-lattice relaxation time (T1) imaging of the heart,was done as soon as MRI machines were available with sufficient apertures to accommodate the human torso in the early 1980's (1). In 1985, studies of patients with 2-12 day old myocardial infarction showed elevations of about two-fold in spin-spin relaxation times (T2) (2), and smaller but significant elevations of about 10% in T1 (3). Eight years earlier, Lauterbur had investigated the effect of a paramagnetic contrast agent (Mn^{++}) to enhance the local T1 differences in the ischemic canine heart (4). Thus, cardiac MR is hardly new, but neither has it had any significant impact on cardiac care: MRI currently has no real place in the diagnosis, the evaluation or the management of heart disease in the clinic.

Yet heart disease is the leading cause of mortality and morbidity in western civilization. When one considers that the primary application of MRI is for neurological conditions and that only a tiny fraction of patients ever undergo MRI, one realizes that a relatively small success in cardiovascular applications could result in a growth of useage of the technology equal again to the whole field to date. But what is that application? In the present cost-conscious environment, MRI would need to compete, complement, or out-perform at least one existing procedure of comparable cost, or perhaps several procedures of lesser cost. This has lead to the concept of MRI as the "one-stop-shop" for heart disease encompassing all or several of the key current cardiovascular diagnostic imaging procedures such as X-ray (fluoroscopy) and coronary catheterization, echocardiography, and radionuclide imaging. However, it is important to recognize that even one good major application could result in a major success.

So why after 20 years is cardiac MR now at a new frontier? The heart has long been a very difficult target for MRI. The images are fraught with artefacts from heart motion, from breathing, from flowing blood in the ventricles, and from irregular motions associated with common heart diseases. It has only been in the last few years that MRI has matured sufficiently in terms of signal-to-noise enhancements (for example, as provided by phased array coils), techniques to

deal with motion (breath-hold, gating, navigator echoes), and methods of stress-testing in the MRI system. Moreover it is now that we see progress on a broad spectrum of sophisticated new MRI technologies for probing coronary artery anatomy and stenoses (5), blood flow, perfusion (6), mechanical function (7), viability and metabolism.

Each of these areas shows great promise but is not without uncertainty, and our laboratory has undertaken projects in each via an inter-departmental collaboration involving Radiology, Biomedical Engineering and Cardiology. The basic vision is a real-time scanner with multi-channel phased-array capable of generating a continuous cine of images with speed, position and orientation parameters that are adjustable on-the-fly. Because we are dealing with critical care patients, the diagnostic information must be available immediately at the end of the exam in order for it to be useful for patient management decisions. Issues of patient monitoring and safety must be addressed. Because of the extreme demands that cardiac MRI places on the technology, cardiovascular MR is today a driving application which will likely impact many areas of MRI, with the potential of revolutionizing the way MRI is done.

References

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