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Cardiac MR—A challenge impossible to overcome? A report from the 11th Annual Scientific Meeting of the ESMRMB

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The European Society of Magnetic Resonance in Medicine and Biology convened its 11th annual scientific meeting (April 20–24, 1994) in the "Hofburg," the former palace of the emperor in Vienna which is one of the most magnificent convention places in the world. The program provided a comprehensive overview of magnetic resonance imaging (MRI) techniques and principles of neuroimaging and body imaging.

Many innovative sites in Europe try to integrate increasingly sophisticated cardiac MR tools as part of their routine MR protocols into the clinical environment to best address diagnostic as well as scientific questions from progressive radiologists, cardiologists, cardiovascular surgeons, and nuclear cardiologists, as well as physiologists and basic scientists. As a result, 10.4% of all the presentations, including educational, plenary, scientific talks, and exhibits, were related to topics of cardiac MR imaging and spectroscopy. Switzerland and the Netherlands are presently dominating the field of cardiac MR in Europe and their cardiac contributions alone represented 26.9% and 15.5% of the total cardiac presentations, respectively (Fig. 1). Cardiac-specific MR techniques such as blood flow quantification using the phase contrast technique (Firmin et al.) or ultrafast MR imaging (Haase et al.) and echo-planar imaging (Mansfield et al.), which had been mainly developed in Europe over the last decade are now widely available and the manufacturers have begun to implement them on commercial MR systems.

A large variety of routine cardiac MR tools are currently part of the clinical MR protocols demonstrating remarkable advantages over conventional modalities like echocardiography and biplane cine-ventriculography for measuring diastolic function (Dendale, A. de Roos et al., abstract 329), volumes and ejection fractions of the right and left ventricle (Scheffknecht et al., abstract 227), analysis of 2D regional wall motion using the "centerline" method (Holman et al., abstract 76), and unique quantification of myocardial strain based on "tagging" techniques (Fischer et al., abstract 223). Scientists from the Institute of Biomedical Engineering and Medical Informatics and Cardiology from the University of Zurich (Stuber et al., abstract 328) applied a novel "slice-following technique" which allows regional analysis of myocardial wall thickness of an initially selected myocardial slice over the entire cardiac cycle. This important feature helps to avoid an overestimation of end-systolic wall thickness, which is a problem for images acquired with standard cine techniques.

A common tool in cardiac MR is the quantification of blood flow in the vessels (Miettunen et al., abstract 380) as well as the heart chambers using the phase contrast technique. Radiologists together with cardiologists and cardiovascular surgeons are collaborating at the General Hospital in Vienna to physiologically monitor the treatment of patients with thromboembolic pulmonary hypertension before and after thromboendarterectomy (Mostbeck et al., abstract 43) and to follow up patients with single lung transplantation (Henk et al., abstract 388). Observer-independent precise MR flow quantification allows reproducible, sensitive, and noninvasive monitoring of hemodynamic changes of pulmonary blood flow, thus providing the surgeons and cardiologists with unique diagnostic information for an optimized treatment of their patients.

Noninvasive MR coronary angiography has recently been introduced by Edelman and Manning et al. at the Beth Israel Hospital in Boston (USA) and has been propagated worldwide. Researchers from the renowned Royal Brompton Hospital in London (Underwood, abstract 21) demonstrated that coronary artery stenoses detected by X-ray angiography could be correctly located with an overall sensitivity of 87%, by assessing the MR coronary angiograms (Pennell et

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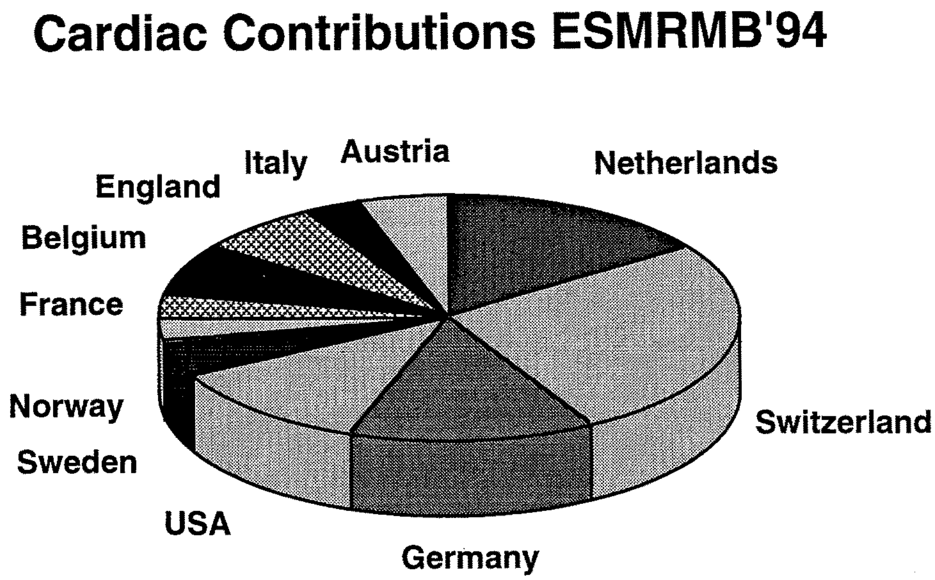

Fig. 1. Cardiac contributions to ESMRMB '94.

al., abstract 374). When comparing coronary artery diameter measurements with quantitative contrast angiography a good correlation ($r = 0.76$, $p < 0.001$) was observed (Scheidegger et al., abstract 375). Despite the fact that MR coronary angiography appears very promising, a great deal of technical improvements are required before this technique is ready for general clinical applications (Duerinckx, abstract 373).

MR first-pass imaging of the heart for studying myocardial perfusion at rest and during pharmacological stress was made possible since the advent of ultrafast MRI. This trend has also been stimulated by the evaluation of new MR contrast agents such as intravascular relaxation (Rommel et al., abstract 224) and T_2^*-sensitive agents (Wetter et al., abstract 75). In various MR centers, MR first-pass studies are now conducted and confirm some of our previous findings that it is possible to identify hypoperfused myocardial regions (Lombardi et al., abstract 226) and that the MR first-pass data are in agreement with the results of nuclear medicine and X-ray angiographic studies (Matheijssen et al., abstract 228). In 88% of patients with a one-vessel disease (>70% stenosed coronary artery!), one can observe a significantly prolonged myocardial mean transit time (van Rossum et al., abstract 172). By combining MR cine or tagging with the MR first-pass technique, cardiac MRI offers a versatile alternative for studying myocardial viability (Miettunen et al., abstract 225). Using intravascular T_1 contrast agents and T_1-weighted ultrafast sequences for first-pass imaging in combination with appropriate perfusion modeling, it is feasible to quantify myocardial blood flow and volume (Wilke et al., abstract 74).

MR researchers at the University Hospital of Zurich upgraded a nonresonant echo-planar MR scanner (1.5 T) and refined it for cardiac imaging; this effort represents a major asset for cardiovascular MR imaging. Suppression of cardiac and respiratory motion artifacts and increased signal-to-noise ratios (Wetter et al., abstract 341), perfusion studies encompassing the entire heart, and improved flow measurements (Debatin et al., abstract 44) are considerable improvements (Debatin, abstract 159) which have now also been tailored to commercial MR scanners (Laub, abstract 173) to further expand the clinical capabilities of state-of-the-art MR cardiac sites. Scientists from the Institute of Biophysics and Cardiology at the University of Würzburg opened the door to a fascinating new research field in cardiovascular physiology and cardiology. Bauer et al. (abstract 80) presented an unique NMR-microscopy study on a perfused rat heart using a high-field MR system (11.7 T). Vessels with a diameter as small as 140 μm could be clearly visualized. This is an unmatched method for studying, for example, the effect of vasoactive substances on the diameter of microvessels, and this might be paramount for the development of a new generation of drugs for the treatment of patients with ischemic heart diseases.

Although metabolic assessment using MR spectroscopy of the heart still remains experimental because of the large measurement voxels using commercial 1.5-T systems, it has been demonstrated that with adiabatic sequences, special surface coil assemblies, and high-field systems (4.7 T), voxels of 1.4 ml are within experimental reach. In combination with wall motion and perfusion sequences it is then possible to perform a comprehensive study assessing noninvasively the morphology, function, and metabolism of the heart (Merkle et al., abstract 507). Similar experimental setups provide new physiological insights when it comes to assess more sensitively cardiac rejection after transplantation (Walpoth et al., abstract 277), to study the metabolic and functional effects of cardiolplegia (Ganghong et al., abstract 278), and to measure intracellular magnesium concentrations after administration of an angiotensin-converting enzyme inhibitor (Carlier et al., abstract 455) to name only a few research applications.

Based on the data presented at the ESMRMB '94, any lingering doubts are removed that cardiac MR does not have the potential to play a paramount role, whether it is in an clinical environment or in the cardiovascular research labs of physiologists and pharmacologists. This is also reflected in the increasing number of cardiac MR workshops (ESC, European Heart House, Education and Training Programs, Cardiovascular MR Techniques: Clinical and Scientific Applications, 1995, FAX: +33-92947601) and the recent founding of a new international cardiac MR society. All cardiologists as well as radiologists dedicated to cardiac MR are encouraged to join the "Society for Cardiac Magnetic Resonance" (SCMR, FAX: 001-609-853-0411), which will meet again at the "American College of Cardiology" conference in 1995. For the clinicians, this is an unique opportunity to open up MR to the largest patient population, that is, the patients with cardiovascular diseases. It is hypothesized that nearly 30% of all cardiovascular diagnostic procedures can be equally or even better addressed by cardiac MR than with other modalities. But, to succeed, a collaborative effort of all the different groups of clinicians involved in the diagnostic and therapeutic management of cardiac patients is necessary, especially in view of today's environment of cost containment and the economic challenges facing the researchers and clinicians. The bleak predictions that this might be an impossible challenge to overcome were disproved by this meeting.