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Nuclear Magnetic Resonance Imaging: With or Without Nuclear?*

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Historical perspective. Nuclear magnetic resonance (NMR) derives its name from the physical property of certain atomic *nuclei* related to their *magnetic* characteristic of *resonating* when placed within a magnetic field and irradiated with radio waves at a specific frequency. This property of the nucleus was first reported in 1946 by two independent laboratories, one at Stanford (Bloch et al. [1]) and the other at Harvard (Purcell et al. [2]). Subsequently, physicists and chemists have developed methods for applying NMR to evaluate chemical composition (NMR spectroscopy [3]), and most recently to obtain diagnostic images (NMR imaging or "magnetic resonance imaging") (4). Several nuclei that exhibit NMR have medical relevance. These include hydrogen-1, carbon-13, sodium-23 and phosphorus-31. During the past 15 years NMR spectroscopy has been applied in vitro to biologic systems to evaluate biochemical composition, pH and enzyme kinetics, and to monitor changes in these induced by clinically relevant perturbations such as ischemia (5).

The most important advance in the application of NMR methods to medicine and clinical cardiology began in 1973 with the descriptions of methods by which images could be generated using NMR (4,6). Subsequently, these descriptions were converted into clinically applicable realities through the investigations of a number of groups in both university and industrial laboratories (7). The hydrogen nucleus (proton) has been the most important imaging target owing to its high magnetic sensitivity and high concentration within the body. Using proton NMR methods, images of the brain, heart and other organs have been generated in exquisite detail (8). In addition, sodium images of the brain depicting ischemic stroke have been generated (9). Ultimately, other nuclei with clinical importance may be imaged.

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NMR terminology: a controversy. In the December 1983 issue of *AJR* (American Journal of Roentgenology) (10) and the January 1984 issue of *Radiology* (11), editorials suggested that the word "nuclear" should be eliminated and NMR imaging should become "magnetic resonance imaging" (MRI). These editorials asserted that "magnetic resonance imaging" was a more descriptive and accurate term. Further, they suggested that the American public would be afraid of the nomenclature of "NMR imaging" if the term "nuclear" were retained.

Subsequently, both *AJR* and *Radiology* have made it editorial policy to eliminate the word "nuclear" from their published papers. Unfortunately, the terminology "magnetic resonance imaging" is not scientifically specific, because there is a type of magnetic resonance that involves the electron (electron spin resonance [ESR] or electron paramagnetic resonance [EPR]). The use of "magnetic resonance imaging" does not specify whether the resonance is taking place in the nucleus or in the electrons. To complicate matters further, there is yet another form of magnetic resonance known as the Mössbauer effect (12). As noted by Bottomley and Edelstein (NMR imaging physicists) in their letter to the editor of the *AJR* (13), the American Institute of Physics style manual (14) lists NMR, ESR and EPR but not MR as accepted abbreviations (see also a similar article by Edelstein and Bottomley [15]). Further, it is unlikely that the American Institute of Physics handbook would ever add MR or MRI as accepted abbreviations. Many scientists (including spectroscopists, chemists and physicists) who have dedicated their careers to NMR were outraged by this change in nomenclature. Unfortunately, this name change from NMR imaging to MRI rapidly metastasized throughout the radiology and medical world. The spread of "MRI" as the term describing NMR imaging was related to the following: 1) most physicians were either unaware or only peripherally aware of this new diagnostic technology and were led to believe that "MRI" was the official term; and 2) manufacturers agreed with the name change in part because it was adopted by the radiologic community and in part because of the potentially bad connotation that the "nuclear" term might give to the technology.

As a result, there now exists considerable confusion with

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respect to terminology. There are two poles. The radiology community has largely converted to the new, scientifically imprecise nomenclature, MRI. Conversely, NMR scientists, some of whom have been in the field for decades, generally consider the classical nomenclature, "NMR imaging," appropriate. While not an issue that would merit a "nuclear" war, it is clearly important to a number of scientists and radiologists.

Conclusions. Although it is probably inappropriate for JACC to make editorial rules regarding nomenclature, it is appropriate to make strong recommendations. We would encourage those who publish in JACC to use the most scientifically precise terminology, "nuclear magnetic resonance (NMR) imaging," rather than magnetic resonance imaging (MRI). If the word "nuclear" is of concern to the public, education is the solution. It should be made clear that the "nuclear" in NMR is *not* related to ionizing radiation, nuclear warfare or nuclear power plants. The term "nuclear" in NMR is used to specify the part of the atom that generates the information as a result of its magnetic properties. It seems inappropriate to change from a traditional name, which is more scientifically descriptive and specific, and which is favored by the scientific community.

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