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EDITORIAL COMMENT

Cardiac Magnetic Resonance Imaging Signal Characteristics of Cardiac Tumors in Children*

Dianna M. E. Bardo, MD

Portland, Oregon

In this issue of the *Journal*, Beroukhim et al. (1), an international group of cardiac imagers, present the cardiac magnetic resonance imaging (MRI) findings in a large number and variety of cardiac tumors in children.

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The history of cardiac imaging began with creation of a radiographic shadow image (x-ray) of the thorax, shortly after the discovery of x-rays by Wilhelm Roentgen, in 1895, when Danzer described the cardiothoracic ratio in 1919 (2). By comparison, cardiac MRI, which became clinically feasible only in the late 1980s, is a young imaging modality (3). The course of development of each cardiac imaging modality includes a somewhat tumultuous road of gaining acceptance within the scientific community and, now more than ever, by the healthcare insurance industry. Each step has, of necessity, led to advances in cardiac imaging technology and research. Using developments in magnetic resonance (MR), cardiac imagers have borrowed sequences from imagers of other anatomy and invented new imaging sequences that provide specialized information about cardiac morphology, function, and assessment of blood flow through chambers and across valves, well beyond that which can be achieved with other individual cardiac imaging modalities.

As magnet and radiofrequency technology has advanced, those working in cardiac imaging have taken full advantage of how properties of tissue composition affect the appearance or signal characteristics of myocardial tissue with cardiac MRI. For example muscle, the myocardium, is basically a water-based tissue (i.e., it contains a large number of hydrogen protons) and therefore is ideally imaged with MRI. Surrounding epicardial and pericardial fat, the fibrous pericardium and indeed infiltrative and invasive tumors that affect the heart show varied MR signal characteristics, because they are composed of tissues that contain varying amounts of water or protons and therefore show differences in or distort the signal characteristics of the normal myocardium. On the basis of tissue composition, MR signal is changed, and in some instances, the histological composition of normal or abnormal tissue can be inferred.

The technologically challenging science of cardiac MRI sequence and protocol development has no doubt inspired the authors to recognize the importance of the possibility of developing specific and sensitive imaging diagnoses of myocardial tumors.

This contribution by the authors is considerable. By elucidating and defining myocardial and neoplastic signal characteristics of cardiac tumors seen in children, although not 100% specific, they enable the radiologist and cardiologist to formulate a diagnosis or differential diagnosis to direct treatment or conservative therapy. The cardiac MRI imaging guidelines outlined advocate establishing protocols that use axial and oblique imaging planes as well as standard, uniform cardiac imaging planes (vertical and horizontal long-axis, short-axis, and left and right outflow tract views) and imaging sequences designed to characterize tissue contents. Their tabulated results not only define specific cardiac MRI image sequences that contribute to distinguishing normal myocardium from several histological subtypes of childhood cardiac tumors but provide the reader with a checklist of tissue characteristics found on cardiac MRI, the possible accompanying imaging findings, and gross appearance of each tumor. Furthermore, the authors offer insight into how to avoid pitfalls of inadequate image quality and tips regarding those sequences that they have found to be particularly helpful in making specific imaging diagnoses and when biopsy is definitively indicated, on the basis of cardiac MRI results.

Cardiac tumors are a very rare diagnosis in children and in adults. Some cardiac imagers might see only 1 or 2 in their career. The strength of this international group of respected imagers is clear, given the large number of cases collected and reviewed. Although the authors recognize that the distribution of tumor histology found in their study does not reflect the expected distribution and frequency of tumor type, there might be a simple explanation. Although rhabdomyoma is one of the most common cardiac tumors in childhood, there were few imaged with MR in this large population. It might simply be that children with rhabdomyoma were less likely to have been referred for cardiac MRI during the study period than children with other suspected types of cardiac tumor, perhaps because echocardiography was deemed to be diagnostic and further imaging with cardiac MRI was not requested. Therefore this phe-

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From the Oregon Health & Science University, Department of Radiology, Portland, Oregon. Dr. Bardo has served on the Speakers' Bureau for and received honoraria from Koninklijke Philips Healthcare.

nomenon might have actually benefitted the authors and readers of this article, because the result is the impressive variety of tumor pathology collected and tabulated. It is the number of types of pathologies included here that has allowed the authors to develop a comprehensive, detailed report of cardiac MRI signal characteristics, which is correlated with gross appearance, for a variety of cardiac tumors.

It is the strength and perseverance of this type of research that will continue to develop the field of cardiac MRI. The comprehensive, noninvasive cardiac MRI examination not only provides insight into distorted cardiac anatomy and clues into the source of a cardiac mass but, when performed with specific pulse sequences as described by these authors, provides the cardiac imager with the tools to characterize normal myocardial tissue and the numerous neoplasms that might affect the heart with greater sensitivity and specificity than is possible with echocardiography, angiography, and computed tomography and certainly with radiography and nuclear medicine.

Molecular imaging is currently a major area of medical imaging research, particularly as applied to neoplasm detection and surveillance. Most biomedical and molecular imaging research in cardiac disease is directed to imaging progression of the effects of atherosclerosis and myocardial infarction (4,5). Imaging of neoplasm in other anatomic regions is increasingly dependent upon the functional imaging modalities such as positron emission tomography; hybrid MR/positron emission tomography scanners are being installed in medical centers worldwide, and research is well underway with paramagnetic (gadolinium)/superparamagnetic (iron oxide) agents for MRI of tumor angiogenesis in brain neoplasm. Molecular or cellular-specific agents labeled with tumor-specific antigens or endothelial growth factors might be delivered to the heart attached to gadolinium or iron oxide. Therefore, it is conceivable that the technology of cardiac MRI and tumor biology imaging could be unified, enabling cardiac imagers to increase specificity and sensitivity for a singular diagnosis, on the basis of a combination of conventional cardiac MRI and molecular imaging techniques.

This current contribution to published medical imaging data will serve as a valuable resource for pediatric cardiologists and pediatric radiologists, as primary caretakers of children, as well as for those who care for adult patients with cardiac tumors. This paper is one reference that I will definitely keep within arm's reach.

Reprint requests and correspondence: Dr. Dianna M. E. Bardo, Department of Radiology, Oregon Health & Science University, 3181 Southwest Sam Jackson Park Road, CR 135, Portland, Oregon 97239. E-mail: dmebmd@gmail.com.

REFERENCES

1. Beroukhim RS, Prakash A, Valsangiacomo Buechel ER, et al. Characterization of cardiac tumors in children by cardiovascular magnetic resonance imaging: a multicenter experience. J Am Coll Cardiol 2011;58:1044–54.
2. Danzer CS. The cardiothoracic ratio: an index of cardiac enlargement. Am J Med Sci 1919;157:513–21.
3. Higgins CB, Holt W, Pflugfelder P. Sechtern U. Functional evaluation of the heart with magnetic resonance imaging. Magn Reson Med 1988;6:121–39.
4. Sosnovik DE, Nahrendorf M, Weissleder R. Molecular magnetic resonance imaging in cardiovascular medicine. Circulation. 2007;115: 2076–86.
5. Kietselaer BLJH, Thimister PWL, Reutelingsperger CPM, et al. Molecular imaging of cell death in intracardiac tumors: a new approach to differential diagnosis in cardiac tumors. Neth Heart J 2002;10:313-7.

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