Cardiac magnetic resonance radiofrequency tissue tagging for diagnosis of constrictive pericarditis: A proof of concept study

John A. Power, BS,[a,b] Diane V. Thompson, MS,[a] Geetha Rayarao, MS,[a] Mark Doyle, PhD,[a] and Robert W. W. Biederman, MD, FACC, FAHA[a]

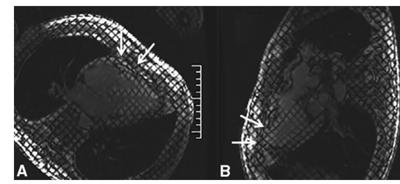
ABSTRACT

Objective: Invasive cardiac catheterization is the venerable ‘‘gold standard’’ for diagnosing constrictive pericarditis. However, its sensitivity and specificity vary dramatically from center to center. Given the ability to unequivocally define segments of the pericardium with the heart via radiofrequency tissue tagging, we hypothesize that cardiac magnetic resonance has the capability to be the new gold standard.

Methods: All patients who were referred for cardiac magnetic resonance evaluation of constrictive pericarditis underwent cardiac magnetic resonance radiofrequency tissue tagging to define visceral-parietal pericardial adherence to determine constriction. This was then compared with intraoperative surgical findings. Likewise, all preoperative cardiac catheterization testing was reviewed in a blinded manner.

Results: A total of 120 patients were referred for clinical suspicion of constrictive pericarditis. Thirty-nine patients were defined as constrictive pericarditis positive solely via radiofrequency tissue-tagging cardiac magnetic resonance, of whom 21 were positive, 4 were negative, and 1 was equivocal for constrictive pericarditis, as defined by cardiac catheterization. Of these patients, 16 underwent pericardiectomy and were surgically confirmed. There was 100% agreement between cardiac magnetic resonance–defined constrictive pericarditis positivity and postsurgical findings. No patients were misclassified by cardiac magnetic resonance. In regard to the remaining constrictive pericarditis–positive patients defined by cardiac magnetic resonance, 10 were treated medically, declined, were ineligible for surgery, or were lost to follow-up. Long-term follow-up of those who were constrictive pericarditis negative by cardiac magnetic resonance showed no early or late crossover to the surgery arm.

Conclusions: Cardiac magnetic resonance via radiofrequency tissue tagging offers a unique, efficient, and effective manner of defining clinically and surgically relevant constrictive pericarditis. Specifically, no patient who was identified with constriction via cardiac magnetic resonance underwent inappropriate sternotomy. However, catheterization had substantial and unacceptable false-positive and false-negative rates with important clinical ramifications. (J Thorac Cardiovasc Surg 2016;151:1348-55)



Magnetic resonance images depicting an example of tissue tagging to delineate the pericardium and myocardium.

Central Message

We present cardiac magnetic resonance imaging tissue tagging to diagnose constrictive pericarditis. Its accuracy and correlation with surgically confirmed pericardiectomy are 100%.

Perspective

Constrictive pericarditis is a difficult disease to diagnose. We present the utility of cardiac magnetic resonance imaging, a noninvasive technology, via radiofrequency tissue tagging diagnose constrictive pericarditis. Its accuracy and correlation with surgically confirmed pericardiectomy are 100%. This approach is viable on all manufacturers' magnetic resonance imaging scanners and is easier, cheaper, safer, and more robust than current modalities.

See Editorial Commentary page 1356.

Constrictive pericarditis (CP) is encountered increasingly in clinical practice and may present with classic symptoms or, more frequently in today's environment, innocuously

Scanning this QR code will take you to the article title page.

From the [a]Department of Medicine Cardiovascular Magnetic Resonance Center, Allegheny General Hospital, Pittsburgh, Pa; and [b]University of Connecticut School of Dental Medicine, Farmington, Conn.

Funding was internal.

Received for publication July 22, 2015; revisions received Dec 4, 2015; accepted for publication Dec 16, 2015; available ahead of print Jan 24, 2016.

Address for reprints: Robert W. W. Biederman, MD, FACC, FAHA, Cardiovascular Magnetic Resonance Imaging, Temple University School of Medicine, Carnegie Mellon University, Allegheny Health Network, Allegheny General Hospital, 320 E North Ave, Pittsburgh, PA 15212 (E-mail: Rbiederm@wpahs.org).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2015.12.035

Abbreviations and Acronyms

CI	= confidence interval
CMR	= cardiac magnetic resonance
CP	= constrictive pericarditis
CT	= computed tomography
MRI	= magnetic resonance imaging
RF	= radiofrequency
SSFP	= steady-state free precession

masquerade as another disorder. CP is elusive. The diagnosis often is unheralded and escapes diagnosis for months and even years, subjecting the patient to a progressive burden that, but for a diagnosis, could be treated surgically relatively easily. However, too often the index of suspicion is low. When coupled with inexact noninvasive and invasive tools to unequivocally make the diagnosis, a vicious circle ensues. Thus, this study seeks to present a straightforward manner in which to unequivocally make a clinical diagnosis of CP and to demonstrate the utility of such an approach in the surgical suite with confirmation of the diagnosis. To be clear, many approaches have been advocated in the past, chiefly reliant on echocardiography, computed tomography (CT), or catheterization. Few have used the emerging new tool of cardiac magnetic resonance (CMR). In the last decade, CMR unfailingly has been demonstrated to be the "gold standard" in a host of cardiovascular disease entities, such as biventricular function, viability, cardiomyopathies, and congenital heart disease, and, more recently, in post–heart transplant recipients. The unique capability to integrate function and physiology not limited by field of view, spatial/temporal resolution, or obligate need for invasive strategy, radioisotopes, or radiation has natural attributes serving to underpin the likelihood for success in this arena. Thus, it would not be unexpected that elucidation of yet another complex pathophysiologic process could be possible via CMR. This study establishes the utility of CMR in CP and provides the surgical basis for its place in the armamentarium of tools available to the physician and particularly to the discerning surgeon facing the consternation of CP.

In brief, the current study defines the anatomic and physiologic issues and quickly reminds the reader of the multitude of imaging and invasive tools currently available to the surgeon for CP while setting the stage for the focus of the CMR CP study.

PERICARDIAL ANATOMY

The pericardium consists of 2 layers: the parietal and visceral layers. In between these layers is 5 to 20 mL of pericardial fluid. The pericardial fluid allows the 2 membranes to slide freely with reduced friction.[1] CP is the fibrosis and calcification of the pericardium, which over time prevents the heart from filling during diastole.[2] A multitude of diseases can cause irritation of the pericardium, in turn leading to CP.[1] In the past, a major cause of CP was tuberculosis.[3] With the decline of tuberculosis cases in the United States, the most frequent current cause of CP in the 21st century is cardiac surgery and radiation therapy.[1,3]

CLINICAL CONUNDRUM

CP is a problematic disease to diagnose.[4] One of the key identifiers in diagnosing constriction is a thickened pericardium. However, it has been shown in contemporary studies that only 80% of patients with surgically proven CP have thickened pericardium (>4 mm).[5] This problem has only intensified as effusive constriction because tuberculosis is seen less often, whereas postpericardiotomy due to surgical intervention is increasingly responsible for contemporary CP. Another major problem with diagnosing CP is that it can mimic diseases as divergent as myocardial infarction and cirrhosis. This is a vexing clinical problem because failure to diagnose accurately leads to delays in correct therapy or inappropriate pericardial stripping.

COMMON TOOLS AVAILABLE FOR DIAGNOSING CONSTRICTIVE PERICARDITIS

Cardiac Catheterization

Historically, most patients presenting with CP have been diagnosed via cardiac catheterization. Cardiac catheterization has been considered the de facto "gold standard" for the evaluation and confirmation of CP.[2] Cardiac catheterization has the ability to determine the equalization of diastolic pressures in the right and left ventricles, the square root sign, and the rapid x and y descents in the atrial pressure curves. However, these signs also can be seen in patients presenting with restrictive disease.[2,5] Ventricular interdependence can be used to differentiate between constriction and restriction, simultaneously using the left ventricular and right ventricular pressures. Patients with constriction will have a decreased wedge pressure during the first beat of inspiration, whereas patients with restrictive disease will not demonstrate a decrease in wedge pressure.[2,5] A negative cardiac catheterization is due to the lack of equilibration of pressures (left ventricular end-diastolic pressure, right ventricular end-diastolic pressure, left atrium, and right atrium), which is determined by the lack of a dip and plateau, also known as a "square root sign." However, cardiac catheterization is invasive and requires a significant amount of training to be proficient. Its sensitivity and specificity are improved only by evaluating cumbersome ventricular interdependence requiring multiple hemodynamic catheters, which, in our experience, is well done in limited laboratories.