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Magnetic Resonance Elastography of the Heart

Thomas Elgeti · Ingolf Sack

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Abstract Cardiac magnetic resonance (MR) elastography noninvasively provides mechanics-based image contrast. The measurement of mechanical parameters is otherwise possible only by palpation or invasive pressure measurement. Measurement of parameters of myocardial shear stiffness is considered to be diagnostically beneficial especially in patients with diastolic dysfunction due to diffuse myocardial disease. Initial results of several single-center studies in animals, healthy volunteers, and patients suggest that cardiac MR elastography is capable of measuring shear stiffness-related diagnostic parameters. The following article shortly reviews the two main approaches used for cardiac MR elastography and outlines the results of the studies performed so far.

Keywords Cardiac MR elastography · Heart · Diastolic dysfunction · Myocardial shear modulus

Introduction

The pumping function of the heart relies on the periodic alteration in myocardial shear modulus.

Ventricular blood ejection, blood circulation, and pressure generation are maintained by the alteration in myocardial shear modulus–the driving force of our vascular system. Magnetic resonance elastography (MRE) of the heart aims at measuring myocardial shear modulus in a noninvasive, image-resolved way. Therefore, cardiac MRE is a unique medical imaging modality that directly probes the source of cardiac function.

Cardiac failure is a considerable health burden and consumes a large share of medical resources. In the United States, more older persons are hospitalized for heart failure than for any other medical condition [1]. Its prevalence increases with age [2], and an estimated 5 million persons in the US and 23 million people worldwide [3] are considered to be affected. It is expected that, with increased aging of the population, the impact of heart failure will rise significantly [1]. To guide and monitor future therapy, proper diagnosis and follow–up of cardiac function are essential.

Traditionally, the diagnosis of cardiac failure has relied on the measurement of left ventricular ejection fraction (LV-EF). Using this approach, cardiac failure with preserved and reduced LV-EF is distinguished. The more severe the systolic dysfunction, the more the EF is reduced and, in general, the greater the end-diastolic and end-systolic volumes [4]. Medical imaging serves to mathematically calculate EF by dividing the stroke volume by end-diastolic volume [4]. While this approach is sufficient to diagnose systolic function, it is more difficult to assess diastolic function. It is known that, in more than half of cases, cardiac failure affects diastolic function [5].

In the past, measurement of volume–pressure- curves [6, 7] were considered the standard of reference for evaluation of diastolic function. Pressure changes in the cardiac chambers result from myocardial contraction and relaxation. Hence, pressure-time curves are directly related to the evolution of the myocardial shear modulus over the cardiac cycle. This measurement is an invasive procedure that is limited in daily clinical practice by the hazardous aortic valve passage in elderly patients [8]. Furthermore, the differentiation between intrinsic

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T. Elgeti (✉)
Klinik und Hochschulambulanz für Radiologie,
Charité - Universitätsmedizin Berlin, Campus Benjamin
Franklin, Hindenburgdamm 30, 12203 Berlin, Germany
e-mail: thomas.elgeti@charite.de

I. Sack
Institut für Radiologie, Charité - Universitätsmedizin Berlin, Campus
Mitte, Charitéplatz 1, 10117 Berlin, Germany
e-mail: ingolf.sack@charite.de