Ventricular Mechanics
Techniques and Applications

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KEYWORDS

• Strain • Magnetic resonance • Cardiac • Imaging • Ventricular mechanics

KEY POINTS

- Regional function of the myocardium can be quantified using myocardial strain analysis.
- Myocardial strain is defined as the relative lengthening of the tissue, thus: a normalized measure of deformation.
- The main parameters used to quantify strain on magnetic resonance imaging are circumferential, longitudinal, and radial strain.
- Many cardiac magnetic resonance techniques have been developed for detection and quantification of regional strain abnormalities including steady-state free-precession cine, tagging, and displacement encoding with stimulated echoes.
- Recent clinical studies have shown potential use of these techniques for risk stratification and treatment guidance in patients with congenital and acquired heart diseases.

INTRODUCTION

Many cardiac diseases do not affect the heart globally in an early stage.[1] Normal global measures such as ejection fraction can therefore be insensitive to these early regional dysfunctions.[2] Thus, the assessment of the regional myocardium function with magnetic resonance imaging (MRI) poses as a novel potentially important tool for early identification of cardiac pathology.

Regional function of the myocardium can be quantified using myocardial strain analysis. Myocardial strain is defined as the relative lengthening of the tissue, thus: a normalized measure of deformation.[3,4] Cardiac MRI (cMRI) is considered the reference standard for measurement of myocardial strain. Some of the cardiac MRI techniques used for measuring regional myocardial functions are myocardial steady-state free precession (SSFP) cine, tagging, displacement encoding with stimulated echoes (DENSE),[1] strain encoding imaging (SENC), and feature tracking techniques.[2]

From a biomechanical point of view, it would be preferable to present the strain given the fiber structure of the heart; however, the complex geometry of the heart makes this challenging. Therefore, the main parameters used to quantify strain on MRI are circumferential, longitudinal, and radial strain (**Fig. 1**). Another measure used to describe deformation is strain rate, which describes the rate at which the strain is changing over time.[5] Finally, it is possible to quantify diastolic function based on myocardial strain. The main parameter used for quantification of diastolic function is the strain relaxation index (SRI), which is calculated based on the relationship of the circumferential strain with strain rate curves.[6]

TECHNIQUES

Steady-State Free Precession Cine

SSFP has been used routinely in clinical practice for quantification of regional myocardial function. Qualitatively, this technique allows for visual

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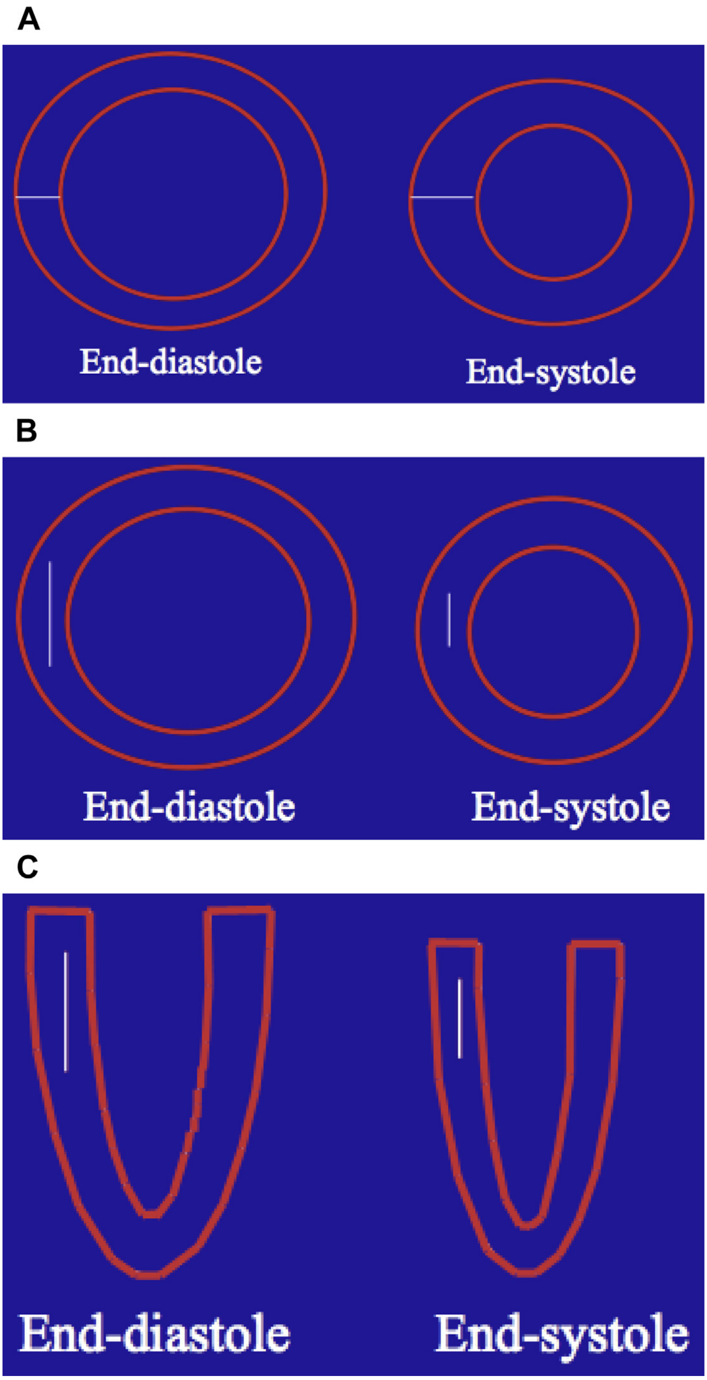

Fig. 1. Parameters for cardiac strain quantification. Diagrams illustrate measurements as changes in distance between 2 points aligned to the transmural myocardial axis for radial strain (*A*), aligned to the circumference of the heart for circumferential strain (*B*), and aligned to the long axis of the heart for longitudinal strain (*C*).

inspection of myocardial thickening during the cardiac cycle in all cardiac regions. Common cardiac planes, named short axis, horizontal long axis, and vertical long axis, provide comprehensive assessment of myocardial contractility in the anterior, lateral, inferior, and septal regions, including the apex, midventricular level, and base of the heart.

In addition to visual assessment of cardiac contractility, postprocessing tools allow for quantification of myocardial thickening during the cardiac cycle, which consists of the increase in myocardial wall thickness from end-diastole to end-systole, and is expressed in millimeters. Measurement of wall thickening in the short-axis plane