Time-Resolved Analysis of Left Ventricular Shear Wave Amplitudes in Cardiac Elastography for the Diagnosis of Diastolic Dysfunction

Thomas Elgeti, MD, † Ingo G. Steffen, MD, † Fabian Knebel, MD, † Robert Hättasch, MD, † Bernd Hamm, MD, † Jürgen Braun, PhD, ‡ and Ingolf Sack, PhD*  

Objectives: The aim of this study was to investigate the diagnostic potential of changes in left ventricular (LV) shear wave amplitudes (SWAs) over the cardiac cycle measured by cardiac magnetic resonance elastography.

Methods: Electrocardiography-triggered SWA-based cardiac magnetic resonance elastography with 24.13-Hz external vibration frequency was performed in asymptomatic young (n = 10) and old (n = 10) subjects and patients (n = 30) with echocardiographically proven mild, moderate, or severe diastolic dysfunction. The temporal delay between change in SWA and morphological change in the LV wall, that is, time of isovolumetric elasticity relaxation normalized against heart rate, was calculated for diastole (τR0). Diastolic levels of LV SWA were calculated and normalized against SWA in the chest wall (U0(dia)). Nonparametric testing was used for statistical evaluation. Accuracy of the parameters was investigated using receiver operating characteristic analysis against echocardiography. Interobserver and intraobserver variability for the temporal delay between change in SWA and morphological changes was tested according to Bland and Altman.

Results: Young and old control subjects showed median (standard error of mean, interquartile range) τR0 of 99 (5, 93–103) and 82 (7, 66–95). In patients with diastolic dysfunction, τR0 was 131 (20, 107–171), 158 (14, 108–172), and 138 (14, 107–174) with statistically significant differences between old subjects and patients with diastolic dysfunction (P < 0.01).

U0(dia) was 0.94 (0.05, 0.86–1.04) and 0.71 (0.06, 0.61–0.92) in young and old controls, respectively (P = 0.063). Compared with young subjects, patients with mild, moderate, and severe diastolic dysfunction displayed significantly reduced U0(dia) of 0.69 (0.06, 0.53–0.82), 0.56 (0.04, 0.46–0.64), and 0.48 (0.04, 0.43–0.61) (P < 0.001).

Conclusions: In diastolic dysfunction, low-frequency SWAs show distinct changes in the normalized time of isovolumetric elasticity relaxation for the LV (τR0) and the diastolic level of SWA (U0(dia)). Both parameters have good diagnostic performance for diagnosis of diastolic dysfunction.

Key Words: magnetic resonance elastography, heart, diastolic dysfunction, cardiac time intervals

Received for publication March 18, 2015; and accepted for publication, after revision, June 30, 2015.

From the †Klinik and Hochschulambulanz für Radiologie, Charité—Universitätsmedizin Berlin, Campus Benjamin Franklin; ‡Klinik für Kardiologie, Angiologie und Pneumologie, Charité—Universitätsmedizin Berlin, Campus Mitte; and †Institut für Medizinische Informatik, Charité—Universitätsmedizin Berlin, Campus Benjamin Franklin, Berlin, Germany.

Conflicts of interest and sources of funding: Ingolf Sack received research grant from the German Research Foundation (Deutsche Forschungsgemeinschaft, Sa 903/7). Bernd Hamm obtained grant money from the following companies or nonprofit organizations to the department of radiology: Abbott, Actelion Pharmaceuticals, Bayer Schering Pharma, Bayer Vital, Bracco Group, Bristol-Myers Squibb, Charité Research Organisation GmbH, Deutsche Krebshilfe, Deutsche Stiftung für Herzforschung, Essex Pharma, EU Programs, FIBREX Medical Inc, Focused Ultrasound Surgery Foundation, Fraunhofer-Gesellschaft, Guerbet, INC Research, InSightee Ud, IPSEN Pharma, Kendell MorphoSys AG, Lilly GmbH, Lundbeck GmbH, MeVis Medical Solutions AG, Nexus Oncology, Novartis, Parexel CRO Service, Perceptive, Pfizer GmbH, Philips, Sanofis-Aventis SA, Siemens, Spectranetics GmbH, Tenmu Medical Corporation, TNS Healthcare GmbH, Toshiba, UCB Pharma, Wyyth Pharma, Zukunftsfonds Berlin (TSB), Argen, Foundation, BARD, Braun, Boehringer Ingelheim, BrainGate, PPD (CRO), CELLACT Pharma, Celgene, CeloNova BioSciences, Covance, DC Devices Inc USA, Gamynd, Gilead Sciences, GlaxoSmithKline, ICON (CRO), Jansen, LUX Biosiences, MED-PASS, Merck, Molten, Nuvisan, Pluristem, Quintiles, Roche, Schumacher GmbH, Seattle Genetics, Symphogen, TauRx Therapeutics Ud, Accovion, Arbeitsgemeinschaft Internistische Onkologie, Advanced Sleep Research, Astellas, Therakos, Galena Biopharma, Chiltern, PRAint, InspireMD, Medtronic, Respicaid, Silena Therapeutics, Spectrum Pharmaceuticals, and St Jude. The remaining authors declare that they have no conflicts of interest.

Correspondence to: Thomas Elgeti, MD, Klinik und Hochschulambulanz für Radiologie, Charité—Universitätsmedizin Berlin, Campus Benjamin Franklin, Hindenburgdamm 30, 12203 Berlin, Germany. E-mail: thomas.elgeti@charite.de. Copyright © 2015 Wolters Kluwer Health, Inc. All rights reserved.

ISSN: 0020-9969/16/0000–0000
DOI: 10.1097/RLI.000000000000198