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Intervendor Differences in the Accuracy of Detecting Regional Functional Abnormalities

A Report From the EACVI-ASE Strain Standardization Task Force

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ABSTRACT

OBJECTIVES The purpose of this study was to compare the accuracy of vendor-specific and independent strain analysis tools to detect regional myocardial function abnormality in a clinical setting.

BACKGROUND Speckle tracking echocardiography has been considered a promising tool for the quantitative assessment of regional myocardial function. However, the potential differences among speckle tracking software with regard to their accuracy in identifying regional abnormality has not been studied extensively.

METHODS Sixty-three subjects (5 healthy volunteers and 58 patients) were examined with 7 different ultrasound machines during 5 days. All patients had experienced a previous myocardial infarction, which was characterized by cardiac magnetic resonance with late gadolinium enhancement. Segmental peak systolic (PS), end-systolic (ES) and post-systolic strain (PSS) measurements were obtained with 6 vendor-specific software tools and 2 independent strain analysis tools. Strain parameters were compared between fully scarred and scar-free segments. Receiver operating characteristic curves testing the ability of strain parameters and derived indexes to discriminate between these segments were compared among vendors.

RESULTS The average strain values calculated for normal segments ranged from −15.1% to −20.7% for PS, −14.9% to −20.6% for ES, and −16.1% to −21.4% for PSS. Significantly lower values of strain ($p < 0.05$) were found in segments with transmural scar by all vendors, with values ranging from −7.4% to −11.1% for PS, −7.7% to −10.8% for ES, and −10.5% to −14.3% for PSS. Accuracy in identifying transmural scar ranged from acceptable to excellent (area under the curve 0.74 to 0.83 for PS and ES and 0.70 to 0.78 for PSS). Significant differences were found among vendors ($p < 0.05$). All vendors had a significantly lower accuracy to detect scars in the basal segments compared with scars in the apex ($p < 0.05$).

CONCLUSIONS The accuracy of identifying regional abnormality differs significantly among vendors. (J Am Coll Cardiol Img 2017;■:■-■) © 2017 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

AUC = area under the curve

AVC = aortic valve closure

CMR = cardiac magnetic resonance

ES = end-systolic

LGE = late gadolinium enhancement

LV = left ventricle

MI = myocardial infarction

PS = peak systolic

PSI = post-systolic index

PSS = post-systolic strain

ROC = receiver operating characteristic

The accurate noninvasive evaluation of regional myocardial function is essential in clinical practice. In heart failure patients with conduction delays, myocardial function can differ significantly between walls, and its accurate assessment could be of potential use for selecting suitable candidates for resynchronization therapy, which would have implications for therapy success and survival (1). After myocardial infarction (MI), the early detection of ischemic injury and the evaluation of myocardial viability directly determines patient management and can prevent serious complications such as sudden cardiac death, left ventricular (LV) remodeling, or arrhythmias (2-4).

In clinical cardiology, cardiac ultrasound is the method of choice for the noninvasive evaluation of regional LV function. In clinical practice, the assessment of regional function abnormalities still relies mostly on the visual interpretation of wall motion abnormalities, which makes it subjective and dependent on skills and experience.

Two-dimensional speckle tracking echocardiography allows the objective quantification of LV global and regional function in a convincingly simple and feasible way. The method has been validated against sonomicrometry and cardiac magnetic resonance (CMR) (5), and global longitudinal strain has proved to be a clinically reliable and reproducible parameter of LV systolic function (6). Likewise, segmental strain measurements have been shown to detect the presence and extent of ischemia (7-13) and distinguish between viable and nonviable myocardial segments (14), which makes them a potential alternative to the conventional "eye-balling" analysis. It is not clear, however, whether current tracking software is sufficiently accurate for this and to what extent the performance of software from different vendors differs.

The present study was designed to evaluate and compare in a clinical setting the accuracy of different software packages to detect regional functional abnormality.

METHODS

STUDY POPULATION. Sixty-three patients, age >18 years, with regular heart rhythm and a previous MI were selected for the study. In all patients, a late gadolinium enhancement (LGE) CMR study had been performed after an MI (without other ischemic events or cardiac interventions before the image acquisitions for this study). Five patients had to be replaced by healthy young volunteers who were on stand-by because of no-show or paroxysmal atrial fibrillation. The study was approved by the ethics commission of the University Hospitals Leuven, and all subjects gave written informed consent before inclusion.

INDUSTRY PARTNER RECRUITMENT. Seven industry partners (Hitachi, Tokyo, Japan; Esaote, Florence, Italy; GE Vingmed Ultrasound, Horten, Norway; Philips, Andover, Massachusetts; Samsung, Seoul, South Korea; Siemens, Mountain View, California; and Toshiba, Otawara, Japan) provided an ultrasound machine, post-processing software, and an application specialist responsible for optimizing the machine settings according to requirements for speckle tracking analysis. Additionally, 2 manufacturers of generic software solutions for speckle tracking analysis (Epsilon, Ann Arbor, Michigan and TOMTEC, Unterschleissheim, Germany) participated in the comparison. One company withdrew from the study for technical reasons. A list of participants and the versions of software used for analysis is provided in Table 1.

STUDY PROTOCOL. **Echocardiographic imaging.** The echocardiographic image acquisitions were completed in 5 days during 9 sessions of 2 to 3 h each. Each patient was scanned by an expert examiner. Seven patients were examined per session each by 1 expert echocardiographer on all 7 ultrasound machines. Application specialists from all companies ensured optimal machine settings during the scans. Images were obtained with the subject in the left lateral decubitus position. Three consecutive cardiac cycles from the apical views (4-, 2-, and 3-chamber) were obtained during breath hold. Additionally, pulsed wave Doppler recordings of the mitral inflow and aortic outflow were acquired for timing measurements. All image data were stored as raw data in a proprietary company format and in the standard DICOM (Digital Imaging and Communications in Medicine) format to allow post-processing with the independent software packages.

CMR imaging. All patients had undergone a CMR study on a 1.5-T Philips Intera-CV (Philips, Best, the Netherlands) using dedicated cardiac software, a phased-array surface receiver coil, and electrocardiography triggering. The CMR acquisitions were performed no sooner than 4 days after the MI. Cine images in horizontal, vertical, and short-axis views were acquired using a breath-hold cine steady-state free-precession sequence. Post-contrast breath-hold T1-weighted 3-dimensional inversion-recovery imaging was used for detection and quantification of LGE 10 min after intravenous bolus of 0.2 mmol/kg