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Effect of Experience and Training on the Concordance and Precision of Strain Measurements

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ABSTRACT

OBJECTIVES This study sought to show the degree to which experience and training affect the precision and validity of global longitudinal strain (GLS) measurement and to evaluate the variability of strain measurement after feedback.

BACKGROUND The application of GLS for the detection of subclinical dysfunction has been recommended in an expert consensus document and is being used with increasing frequency. The role of experience in the precision and validity of GLS measurement is unknown, as is the efficacy of training.

METHODS Fifty-eight readers, divided into 4 groups on the basis of their experience with GLS, calculated GLS from speckle strain analysis of 9 cases with various degrees of image quality. Intraclass correlation coefficients (ICCs), mean difference, standard deviation (SD), and coefficient of variation (CV) were compared against the measurements of a reference group that had experience with >1,000 cases of strain measurement. Individualized feedback was distributed, and repeat measurements were performed by 40 readers. Comparisons with the baseline variation provided information about whether feedback was effective.

RESULTS The ICC for GLS was significantly greater than that for ejection fraction regardless of image quality. Experience with strain measurement affected the concordance in strain values among the readers; the group with the highest level of experience showed significantly better ICC than those with no experience, although the ICC of the inexperienced readers was still very good (0.996 vs. 0.975, $p = 0.0002$). As experience increased, the mean difference, SD, and CV became significantly smaller. The CV of segmental strain analysis showed significant improvement after training, regardless of experience.

CONCLUSIONS The favorable interobserver agreement of GLS makes it more attractive than ejection fraction for follow-up of left ventricular function by multiple observers. Although experience is important, the precision of GLS was high for all groups. Training appears to be of most value for the assessment of segmental strain. (J Am Coll Cardiol Img 2016;■:■-■) © 2016 by the American College of Cardiology Foundation.

Interinstitutional agreement regarding measurement of left ventricular (LV) function is vital for both clinical practice and research. Ejection fraction (EF) is used widely for this purpose, but its limitations are well known. Global longitudinal strain (GLS) is a robust marker of subclinical cardiac dysfunction that appears to be more sensitive for the detection of early change in LV function than EF (1); however, the possible sources of variation in strain imaging (reader, equipment, and subject)

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ABBREVIATIONS AND ACRONYMS

CV = coefficient of variation

EF = ejection fraction

GLS = global longitudinal systolic strain

ICC = intraclass correlation coefficients

LV = left ventricular

MD = mean difference

have not been fully evaluated (2). Indeed, most of the literature on strain analysis has reported on measurements performed by experienced observers, and the nature and length of the learning curve remain undefined. There is a precedent for the deployment of educational interventions to obtain better concordance and improve diagnostic accuracy in echocardiography (3,4), and similar processes to achieve an adequate level of concordance should be considered in the development of clinical trials using strain; however, little is known about whether education or feedback improves strain concordance. Accordingly, we sought to determine whether: 1) levels of experience affect precision and validity (as defined by an expert reference read); 2) GLS has better concordance than EF; and 3) whether strain concordance is improved after feedback.

METHODS

STUDY DESIGN. Echocardiograms from 9 cases with various levels of image quality were prepared for this study, 4 with good image quality and easy automated tracking, 2 with borderline quality in which strain was measurable after adjustments of tracking, and the remaining 3 with images too poor to analyze (included to determine whether observers would avoid measurement). All of the prepared images for analysis were acquired by use of standard commercial echocardiographic systems (Vivid 7 and E9, GE Medical, Milwaukee, Wisconsin). All images were recorded with the highest frame rate (55 to 80 rpm) and optimized image depth and sector width. Each observer calculated EF using the biplane method of disks (5) and obtained strain measurements using commercially available software (EchoPAC PC, GE Medical), with either version 12.0.0 or version 13.0.0 for all reads (6). Measurement of GLS has been described previously (2). GLS was obtained by averaging 3 apical views. An 18-segment model was used for segmental strain analysis.

PROTOCOL 1. GLS for 4 cases with adequate measurement quality was measured by 58 readers with various levels of strain experience from North America, Europe, Asia, and Oceania. Readers were divided into 4 groups by strain experience: no experience (0 cases), limited experience (1 to 20 cases), intermediate experience (21 to 100 cases), and highly experienced (>100 cases). Average strain measurements from 5 highly experienced readers with >1,000 cases of experience (the reference group) were compared with those from these 4 groups for assessment of precision.

PROTOCOL 2. GLS, segmental strain, and 2-dimensional EF of all 9 cases were assessed by a subgroup of 40 readers with different levels of experience (less experienced, ≤100 cases; experienced, >100 cases) from 22 different institutes. Readers were instructed not to measure EF or strain if they thought image quality was inadequate. Each reader received personalized feedback from expert review of the strain tracings in the core laboratory. After training, a set of 6 cases (excluding those with inadequate images) were remeasured by all readers in a blinded manner. Peak longitudinal strains from each segment were compared with average segmental values from the reference group. Protocol 2 was part of an international multicenter trial of the incremental value of myocardial strain for the detection of cardiotoxicity (SUCCOUR [Strain Surveillance During Chemotherapy for Improving Cardiovascular Outcomes], ANZCTR [Australian New Zealand Clinical Trials Registry] number ACTRN12614000341628, approved by the institutional review board of each institution).

All authors had full access to and take responsibility for the integrity of the data.

STATISTICAL ANALYSIS. Intraclass correlation coefficients (ICCs) of GLS and EF were used to determine concordance and improvement of agreement. The difference in GLS and segmental strain between each reader and the reference reads was calculated. Mean difference (MD), standard deviation (SD), and coefficient of variance (CV) were compared with the values from the reference group. Student *t* test and paired *t* tests were used to compare continuous variables when appropriate. The Kruskal-Wallis test was used for comparisons among groups, followed by pairwise comparisons, with the p value adjusted for multiple comparisons. The Jonckheere-Terpstra test was used to test the trend among the groups. Statistical analyses were performed with IBM SPSS statistics version 20.0.0 (SPSS Inc., Chicago, Illinois) and R version 3.1.0. (R Foundation for Statistical Computing, Vienna, Austria) with the "cocron" package. All p values reported are from 2-sided tests, and $p < 0.05$ was considered statistically significant.

RESULTS

PATIENT CHARACTERISTICS. Indications for echocardiography were predominantly for the detection of subclinical LV dysfunction in asymptomatic patients; case descriptions are summarized in Online Table S1. Cardiac volumes were within the normal range (end-diastolic volume 106 ± 21 ml, end-systolic volume 44 ± 12 ml), and patients had preserved EF (59 ± 4%).