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Electrocardiographic Criteria for the Diagnosis of Left Ventricular Hypertrophy

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ABSTRACT

BACKGROUND Current electrocardiographic (ECG) criteria for the diagnosis of left ventricular hypertrophy (LVH) have low sensitivity.

OBJECTIVES The goal of this study was to test a new method to improve the diagnostic performance of the electrocardiogram.

METHODS The study was divided into 2 groups, a test and a validation cohort. In the test cohort, 94 patients were analyzed, including 47 with the diagnosis of hypertensive crisis and 47 with normal blood pressure at admission. Echocardiography was used to estimate the left ventricular mass index. Area under the curve (AUC) analysis was used for comparison of single and combined leads. The McNemar test was used to assess agreement among the ECG criteria against the left ventricular mass index. The proposed ECG criteria involved measuring the amplitude of the deepest S wave (S_D) in any single lead and adding it to the S wave amplitude of lead V_4 (SV_4). Currently accepted LVH ECG criteria such as Cornell voltage and Sokolow-Lyon were used for comparison. The validation cohort consisted of 122 consecutive patients referred for an echocardiogram regardless of the admitting diagnosis.

RESULTS The S_D was the most accurate single lead measurement for the diagnosis of LVH (AUC: 0.80; $p < 0.001$). When both cohorts were analyzed, the $S_D + SV_4$ criteria outperformed Cornell voltage with a significantly higher sensitivity (62% [95% confidence interval [CI]: 50% to 72%] vs. 35% [95% CI: 24% to 46%]). The specificities of all the criteria were ≥90%, with no significant difference among them.

CONCLUSIONS The proposed criteria for the ECG diagnosis of LVH improved the sensitivity and overall accuracy of the test. (J Am Coll Cardiol 2017;69:1694–703) © 2017 by the American College of Cardiology Foundation.

Several electrocardiographic (ECG) criteria have previously been proposed to diagnose left ventricular hyperthrophy (LVH), with modest differences in the degree of accuracy among them (1,2). At present, 37 different ECG criteria have been endorsed by the American Heart Association, a figure that suggests lack of consensus and often leads to confusion among clinicians (3,4). The specificity of the Cornell voltage criteria, the method considered to be the most accurate, is approximately 90%, with a sensitivity of only 20% to 40% (1,5).

In the present study, we tested the performance of novel criteria, taking into consideration the dynamic changes in voltage that occur within each electrocardiogram. We hypothesized that the summation of the amplitude of the deepest S wave in any lead (S_D) with the S wave in lead V_4 (SV_4) would improve upon the sensitivity of the other criteria, while maintaining an adequate specificity for the diagnosis of LVH.

METHODS

POPULATION. After obtaining approval from the institutional review board, 2 different cohorts of patients were selected (the test and the validation cohorts) based on the presumptive incidence of LVH. For the test cohort, all patients admitted to our

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institution from August to September 2013 with an available echocardiogram and electrocardiogram obtained during the same hospitalization were analyzed. The first 50 consecutive patients who were admitted under the diagnosis of hypertensive crisis and 50 additional patients with normal blood pressure and no major cardiovascular disease were selected. Ultimately, 6 individuals (3 from each group) were

SEE PAGE 1704

excluded from the analysis due to limited echocardiographic windows, leaving 94 patients for the study. Hypertensive emergency was defined as systolic blood pressure >180 mm Hg or diastolic blood pressure >120 mm Hg, with evidence of end-organ damage as defined by the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (Joint National Committee 7) (6). Hypertensive urgency was defined using the same cutoffs for blood pressure measurement but with no evidence of end-organ damage.

For the validation cohort, we selected the first 150 patients referred to our institution for an echocardiogram from January 2014 to February 2014 who had a concomitant electrocardiogram for review. The patients were selected regardless of the initial admitting diagnosis. Twenty-eight patients were not included in the analysis due to poor echocardiographic windows. In both cohorts, all patients with complete left or right bundle branch block or ventricular paced rhythm were excluded from the study.

Statistical analysis showed that with 100 patients in the test cohort (equal number of patients with hypertensive crisis and nonhypertensive crisis), there would be >90% power to detect a significant area under the curve (AUC) of 0.7 (vs. the null hypothesis of AUC of 0.5).

ECHOCARDIOGRAPHIC ANALYSIS. Transthoracic echocardiography was used as a method of reference to estimate left ventricular mass (3). Left ventricular

ABBREVIATIONS AND ACRONYMS

AUC = area under the curve

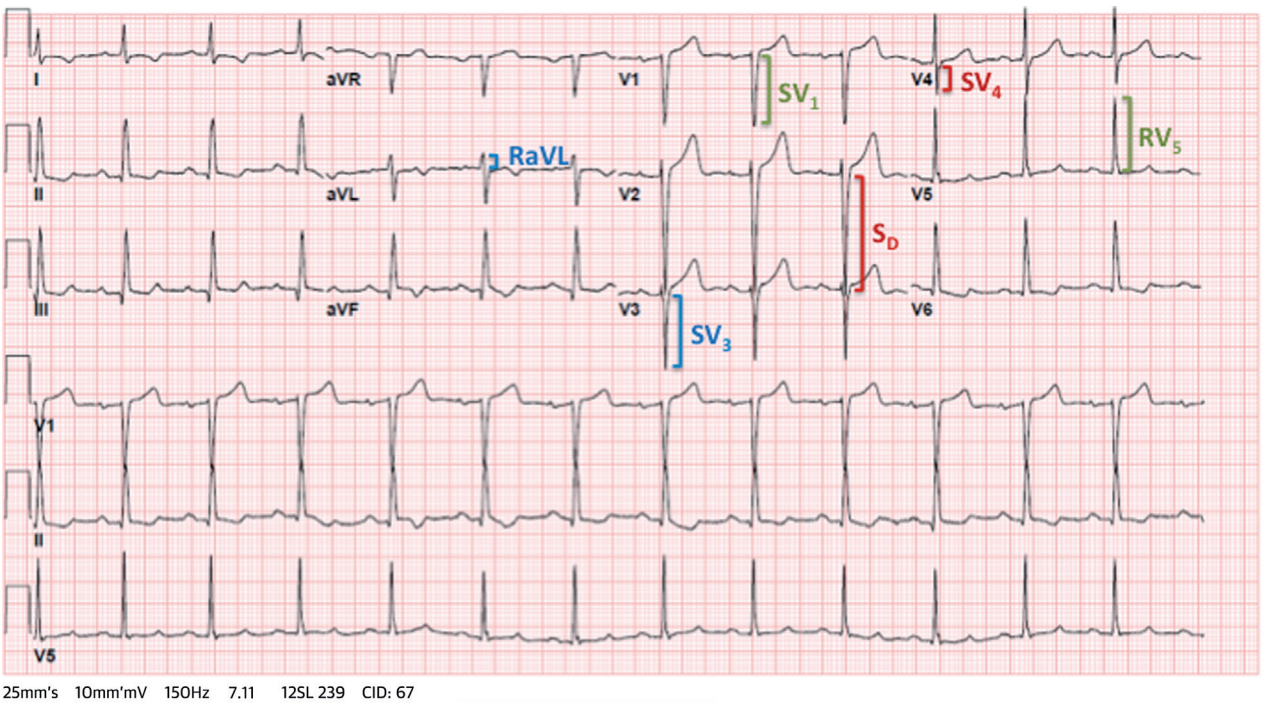
ECG = electrocardiographic

CI = confidence interval

LVH = left ventricular hypertrophy

S_D = deepest S wave in any lead

FIGURE 1 Sample Electrocardiogram



Electrocardiogram of a 71-year-old man that meets criteria for left ventricular hypertrophy based on the Peguero-Lo Presti criteria (deepest S wave in any lead and S wave in V_4 [$S_D + SV_4$]; 2.6 + 0.7 = 3.3 mV [male subjects ≥2.8 mV]). The diagnosis of moderate left ventricular hypertrophy was confirmed by echocardiogram (left ventricular mass index = 145 g/m^2). Note that most common classical electrocardiographic criteria are not met: Cornell voltage (RaVL+ SV_3; 0.4 + 1.6 = 2 mV [male subjects >2.8 mV]) and Sokolow-Lyon voltage (SV_1 + [RV_5 or RV_6]; 1.5 + 1.6 = 3.1 mV [male subjects ≥3.5 mV]).