Advantages and drawbacks of the ECG as a diagnostic tool, main causes and etiologies of left ventricular hypertrophy according to the age group

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I) **Advantages of the ECG for Left Ventricular Hypertrophy diagnosis**

1) Low cost;

2) Easy application in a great universe;

3) Carrying out the trace requires less knowledge of who is taking the examthan echocardiography and other imaging methods

4) Acceptable specificity (between a range of 85% 90% (Hancock et al., 2009;Rautaharju et al., 1996);

5) Simple diagnostic criteria;

6) Possibility of identifying ischemia, necrosis, arrhythmias dromotropic disturbance, waves duration, shape and voltage, segments and intervals, as well as the presence of inconstant waves like delta, Osborn or J-wave, and epsilon;

7) Current role of electrocardiography in the assessment of LVH will move beyond the imprecise estimation of LV mass to decoding its primary information - the electrical properties of hypertrophied myocardium (**Bacharova 2014c**).

8) In childhood HCM increased ECG-amplitudes are a significant risk factor for sudden death, which is independent of echocardiographic measures of hypertrophy (Ostman-Smith et al., 2005).

9) It requires less experience of who conducts the exam.

10) Irreplaceable in apical hypertrophic cardiomyopathy when revealing the typical giant negative T waves from $V_2$to V_5 accompanied by positive voltage criteria.

10) Utility, in preparticipation screening is a life-saving and cost-effective strategy in young athletes in whom SCD is mostly caused by ECG-detectable heart muscle diseases (Corrado, Basso, & Thiene, 2012). Addition of ECG to preparticipation screening saves 2.06 life-years per 1000 athletes at an incremental total cost of $89 per athlete and yields a cost-effectiveness ratio of $42 900 per

life-year saved (95% CI, $21 200 to $71 300 per life-year saved) compared with Cardiovascular-focused history and physical examination alone (Wheeler, Heidenreich, Froelicher, Hlatky, & Ashley, 2010).

11) The ECG criteria for LVH provide independent information on the cardiovascular risk even after adjusting for LVM (**Bacharova 2014**C) independent of increased LVM (Bacharova & Estes, 2017).

12) The ECG remains the most widely used clinical screening tool for the detection of LVH, and yet existing diagnostic criteria are increasingly insensitive due to their inaccuracy in higher body weights. Adjusting the Sokolow–Lyon index by +4 mm in patients with overweight (body mass index (BMI) is 25–30 kg/m2) and by +8 mm in patients with obesity (BMI >30 kg/m2) improves the diagnostic accuracy for detecting LVH. This simple, clinically usable adjustment criterion significantly improves the power of the ECG to detect LVH. Improving the diagnostic accuracy of the ECG should increase the number of patients identified with asymptomatic end organ damage in at-risk populations, improve risk stratification and may reduce the need for further unnecessary investigation **(Rider OJ, Ntusi N, Bull SC, et al. Improvements in ECG accuracy for diagnosis of left ventricular hypertrophy in obesity Heart. 2016;102(19):1566-72**.)

13) The ECG in apparently healthy asymptomatic subjects identifies subgroups at high risk of cardiovascular diseases. Thus, the resting ECG is an office-based test capable of identifying symptomless heart disease and determining which patient should be referred for further non-invasive testing or cardiac catheterization (Khane, Surdi, & Bhatkar, 2011).

14) Each of the six ECG abnormalities comprising the Romhilt–Estes score is independently predictive of cardiovascular disease, and each is different from the other five in predicting specific cardiovascular outcomes (Bacharova & Estes, 2017) consequently, the R-Escore, traditionally used for detection of LVH, could be used as a useful tool for predication of adverse outcomes (Estes, Zhang, Li, Tereschenko, & Soliman, 2015;Estes, Zhang, Li, Tereshchenko, & Soliman, 2015);

15) The adverse prognostic ability of the ECG in patients with so-called false negative ECG results is also documented.

16) Hypertension-induced remodeling as well as hypertrophy are associated with enhanced replacement and diffuse fibrosis, consistent with results of experimental and clinical studies. These results suggest that MRI/LVH and ECG/LVH are different and are related through their common relationship with another underlying and antecedent pathophysiologic state.

Drawbacks of ECG for LVH diagnosis

1) Electrocardiography is too insensitive to be used alone to screen for LVH. Sensitivity: 20% to 60%, (usually less than 50%) (Devereux, Casale, Eisenberg, Miller, & Kligfield, 1984). Only 3% of the general population and 5% of hypertensive patients show LVH in ECG. ECG criteria should not be used to rule out LVH in patients with hypertension Consequently, the ECG for LVH detection in hypertension is not satisfactory considering the low sensitivity and varying specificity (Pewsner et al., 2007).

2) ECG criteria have poor sensitivity for LVH at acceptable levels of specificity and perform less well in women than men, even when sex-specific criteria are used. Sex affects both the prevalence rates and prognostic values of ECG LVH criteria in the general population, while showing higher prognostic value of ECG LVH in women than in men. For clinical use, the composite of the Sokolow-Lyon voltage and the Cornell voltage seems to be a good option (Porthan et al., 2015). ECG changes are an insensitive means of detecting LVH (patients with clinically significant left ventricular hypertrophy seen on echocardiography may still have a relatively normal ECG.

3) The electrocardiographic diagnosis of LVH is difficult in individuals aged under 40. Voltage criteria lack specificity in this group because young people often have high amplitude QRS complexes in the absence of left ventricular disease. (Edhouse J1, Thakur RK, Khalil JM. ABC of clinical electrocardiography. Conditions affecting the left side of the heart. BMJ. 2002 May 25;324(7348):1264-7.)

4) The sensitivity of the ECG for detecting left ventricular pressure overload is substantially lower (<35%) than the sensitivity for detecting evidence of a cardiomyopathy (55% to around 87%) (Ostman-Smith, 2014).

5) Criteria for ECG diagnosis of LVH have a low diagnostic accuracy (Man et al., 2012).

6) Based on the assessment of 250 children, comparing 2D-LVM measurements by echocardiogram and several diagnostic criteria for LVH by ECG, Bratincsák et al. concluded that the ECG, is not a reliable diagnostic test for LVH in young individuals regardless of which diagnostic criteria are employed. The dismal sensitivity renders the ECG unable to detect LVH with any reliability and therefore undermines a screening process by false reassurance of normalcy. The data of theses authors showed that the ECG has dismal sensitivity, acceptable but variable specificity, poor positive predictive value (PPV), and barely acceptable **negative** predictive value (NPV) for the detection of LVH when compared with 2D-LVM by echocardiogram (Bratincsák A, Williams M, Kimata C, Perry JC. The Electrocardiogram Is a Poor Diagnostic Tool to Detect Left Ventricular Hypertrophy in Children: A Comparison with Echocardiographic Assessment of Left Ventricular Mass. Congenit Heart Dis. 2015 ;10(4):E164-71.).

7) **Race** differences ECG criteria of LVH have a poor sensitivity in both black and white hypertensives and a lower specificity in blacks than in whites; this may lead to a greater number of false-positive diagnoses in black patients, as well as to an overestimation of black-white difference in LVH prevalence (Lee, Marantz, Devereux, Kligfield, & Alderman, 1992). Additionally, left ventricular wall thickness but not left ventricular mass is consistently increased in blacks as compared with whites(Devereux, Okin, & Roman, 1998).

8) **Age** in children, the ECG is a poor diagnostic tool to detect LVH. The ECG's prediction of LVH is unreliable with dismal sensitivity, variable specificity, poor positive predictive value, and barely acceptable negative predictive value. With such overall poor reliability, the use of current ECG standards in screening for LVH warrants reassessment (Bratincsak, Williams, Kimata, & Perry, 2015). In centenarians LVH and a specific ST-T wave abnormalities is observed in≈30.95% of cases (**Ba**sile G, Cucinotta MD, Figliomeni P, Lo Balbo C, Maltese G, Lasco A.Electrocardiographic changes in centenarians: a study on 42 subjects and comparison with the literatureGerontology. 2012;58(3):216-20.).

9) Low specificity to determine the enlargement modality;

10) Inverse ratio between sensitivity and specificity of ECG criteria for LVE: the greater the sensitivity, the smaller the specificity and vice-versa;

11) Sensitivity and specificity are affected in concomitance of: RVE/RVH, myocardial infarction, bundle branch block by use of drugs.

12) In transcatheter aortic valve replacement (TAVR) patients, none of the ECG LVH criteria should be used for evaluation of LV mass. QRS duration is moderately correlated to LV mass and is the most useful ECG estimate of LV mass (Sjoberg et al., 2015).