EDITORIAL

Electrocardiography in pulmonary hypertension

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Chronic thromboembolic pulmonary hypertension (CTEPH) is a severe chronic disease caused by obstruction of pulmonary arteries by organized thrombi accompanied by microvascular remodeling.[1] Elevated pulmonary artery pressure leads to enlargement of the right ventricle and right atrium which can be reflected by several electrocardiographic (ECG) parameters. Despite the rapid development of advanced diagnostic methods, ECG continuously attracts the attention of cardiovascular research groups because it is a widely used, easily available, inexpensive, and noninvasive diagnostic tool included in the medical curriculum.[2] In 2009, the American Heart Association, the American College of Cardiology Foundation, and the Heart Rhythm Society proposed 24 criteria for ECG diagnosis of right ventricular hypertrophy which were based mainly on histological studies of the heart. The clinical utility of these criteria were further evaluated by several groups, usually in patients with precapillary pulmonary hypertension (PH).[3] Accordingly, ECG was tested as a tool to screen for PH, to determine prognosis of patients with established PH, and to monitor treatment outcomes.

ECG is currently recommended as an additional diagnostic tool in PH, giving priority to echocardiography in screening for PH and to the right heart catheterization in diagnosing PH. However, despite a relatively low sensitivity and specificity, ECG is still useful at an early stage of PH diagnostic workup. Sawada et al[4] demonstrated that a school ECG-based mass screening program in the general Japanese pediatric population allowed diagnosis of pulmonary arterial hypertension (PAH) at an early asymptomatic phase. In another study, Kovacs et al[5] showed that ECG accuracy to screen for PH may be substantially improved by combining it with other noninvasive tests. They proposed a 2-step algorithm based on ECG (right axis deviation), N-terminal pro-B-type natriuretic peptide (NT-proBNP) level, arterial oxygen saturation, and World Health Organization Functional Class (WHO FC). The algorithm, when used in a group of patients suspected for PH, discriminated well between those with PH and those without, with the positive and negative predictive values of 93% and 96%, respectively.

Several ECG abnormalities, including an increase in the P-wave amplitude in lead II, P-wave duration, resting heart rate, precordial electrocardiogram voltage (sum of the R-wave amplitude in lead V_1 and maximum S-wave amplitude in lead V_5 or V_6), QRS, and QTc duration and the presence of qR in lead V_1 were shown to impact prognosis of patients with PAH or CTEPH.[6] Importantly, the number of ECG abnormalities increases with the progression of PH, as shown recently by Tonelli et al.[7] They compared ECG of patients with PAH at the time of diagnosis and at the time close to death and observed that close to death there was an increase in heart rate, PR interval length, QRS duration, QTc duration, R/S amplitude ratio in lead V_1 as well as rightward rotation of QRS axis and more common occurrence of right bundle-branch block and negative T waves in inferior leads. They found that at the time of death, all patients with PAH had abnormal ECG.

In the last decades, advances in the treatment of PAH and CTEPH[1,8] allowed several groups to show significant improvement in pulmonary hemodynamics, which resulted in reverse remodeling of the right heart chambers. The use of high doses of epoprostenol combined with endothelin receptor antagonists and phosphodiesterase-5 inhibitors early after diagnosis of PAH resulted in a significant drop in mean pulmonary artery pressure in several reports, mostly in the Japanese population, but also in Polish patients.[9] These hemodynamic effects resulted in improvement of several ECG parameters including the R-wave amplitude in lead V_1, QRS axis, S-wave amplitude in lead V_1, R/S amplitude in lead V_6, ventricular activation time and right ventricular strain in leads V_2 through V_4.[10] Importantly, Japanese patients in whom the R-wave amplitude in lead

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V_1 decreased had better survival than other patients. Survival benefit of the R-wave amplitude reduction in lead V_1 was also documented by Polish authors in a group of 80 patients with PAH and CTEPH.[11]

Recent advances in interventional treatment of inoperable CTEPH patients by balloon pulmonary angioplasty (BPA) resulted in excellent hemodynamic effects.[1] In this issue of the *Polish Archives of Internal Medicine* (*Pol Arch Intern Med*), Piłka et al[12] analyzed changes in ECG markers of right ventricular hypertrophy in a large group (n = 41) of patients with inoperable CTEPH treated with BPA. They showed that a change of pulmonary vascular resistance after BPA correlates with changes of the axis of QRS complex and T waves, R/S amplitude ratio in lead V_5, and amplitudes of the following waves: P in lead II and III, S in leads V_5, V_6, and I. The hemodynamic effect of their treatment was remarkable (change of median mean pulmonary arterial pressure from 50 mm Hg to 27 mm Hg) which resulted in anticipated ECG improvement. In this way, the authors confirmed the results of previously published studies.[13,14] The paper also provides novel and clinically useful data comparing changes of several ECG parameters in relation to the hemodynamic effect of BPA. Based on these data, it might be suspected that the T-wave axis, P-wave amplitude in lead II, and R-wave amplitude in lead V_6 are very sensitive to pulmonary vascular resistance reduction. On the other hand, improvements in the other ECG parameters (QRS axis, S-wave amplitude in V_5, R/S ratio in lead V_5, ST-T segment depression or negative T waves in leads V_1 throug V_3 or more precordial leads, and negative T waves in leads II, III, aVF) might predict a significant hemodynamic improvement after BPA. An additional, prospective study would be needed to validate these findings. However, there still remains a question whether these ECG data give us any more information about BPA effectiveness than those based on symptoms, NT-proBNP level, and echocardiography. It is also crucial to understand the pathophysiology of the particular ECG changes. Asano et al[15] in their recent study showed that prolonged QRS duration together with older age predict poor recovery of the RV function after BPA despite good hemodynamic results. They also showed that QRS duration correlated with the area of fibrosis in the right ventricle.

While Piłka et al[12] are to be congratulated on their interesting paper, there still are several important questions about the role of ECG monitoring in patients with CTEPH treated with BPA to be answered. These include its prognostic impact in terms of physical fitness, the risk of hospitalization, and survival. A large cohort and multicenter approach are required to answer this question.

ARTICLE INFORMATION

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