Echocardiographic Pattern of Acute Pulmonary Embolism: Analysis of 511 Consecutive Patients

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Background: There is no comprehensive analysis of transthoracic echocardiographic findings of pulmonary embolism (PE). The aim of this study was to assess the frequency of right ventricular (RV) dysfunction (RVD), typical echocardiographic signs of acute PE (TES), and incidental abnormalities.

Methods: A single-center, retrospective analysis was conducted of 511 consecutive patients (281 women; mean age, 64.0 ± 18.6 years) with PE confirmed by contrast-enhanced multidetector computed tomography who underwent transthoracic echocardiography for the assessment of left ventricular and RV alterations. The McConnell sign, the "60/60" sign, and right heart thrombus were regarded as TES. RVD included RV free wall hypokinesis and RV to LV end-diastolic ratio > 0.9. Incidental echocardiographic alterations were also reported.

Results: RV enlargement, RV free wall hypokinesis, and interventricular septal flattening were found in 27.4%, 26.6%, and 18.4% of patients, respectively. Tricuspid regurgitation peak systolic gradient > 30 mmHg and pulmonary ejection acceleration time < 80 msec were measured in 46.6% and 37.2% of patients, respectively. RVD was found in 20.0% of patients, while normal RV function was present in 33.4% of patients. The McConnell sign, 60/60 sign, and right heart thrombus were found in 19.8%, 12.9%, 1.8% of subjects, respectively. All 16 hemodynamically unstable patients with PE presented enlarged hypokinetic right ventricle and at least one TES. However, in three of them, RV to LV end-diastolic ratio was <0.9. Incidental abnormalities were found in 9.6% of 364 stable patients with PE without RVD and TES.

Conclusions: Transthoracic echocardiography showed no significant abnormalities suggestive of PE in 71% of patients with PE, while in approximately 10%, transthoracic echocardiography revealed incidental findings. The coexistence of an enlarged hypokinetic right ventricle with the McConnell sign together with the 60/60 sign seems to be the most useful echocardiographic criterion for RVD. (J Am Soc Echocardiogr 2016;■:■-■.)

Keywords: Pulmonary embolism, Echocardiography, Diagnosis

Suspected high-risk acute pulmonary embolism (PE) presenting with shock or hypotension is a life-threatening situation, and according to international guidelines it requires urgent diagnostic workup and therapy.[1] When immediate computed tomographic angiography is not feasible, transthoracic echocardiography (TTE) can provide evidence of right ventricular (RV) dysfunction (RVD) justifying lifesaving primary thrombolysis. In normotensive patients, TTE is not recommended as a diagnostic tool, but it can be performed for risk stratification in this group. RVD, when detected, indicates a worse prognosis.[1-4] Moreover, because TTE is one of the most available noninvasive imaging methods, it is also frequently included in the diagnosis of acute dyspnea, chest pain, and hemodynamic decompensation. In patients with PE, TTE can show not only RVD but also in some cases more typical echocardiographic signs of acute PE (TES). The McConnell sign, defined as hypokinesis of the RV free wall with normal contraction of the apical segment (Figure 1, Video 1; available at www.onlinejase.com)[5]; the "60/60" sign, the coexistence of shortened pulmonary ejection acceleration time (AcT) (<60 msec) with midsystolic velocity deceleration ("notch") measured in the RV outflow tract and tricuspid regurgitation peak systolic gradient (TRPG) < 60 mmHg (Figure 2)[6,7]; and right heart thrombus (Figure 3, Video 2; available at www.onlinejase.com)[8] strongly suggest PE, even if not suspected. Moreover, echocardiography can also reveal alternative causes of the observed clinical picture, such as cardiac tamponade, left ventricular (LV) systolic dysfunction, and unexpected significant valvular lesions. The clinical manifestation of PE is often nonspecific, sometimes even suggestive of other cardiopulmonary pathologies. Therefore, because echocardiography can reveal

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Abbreviations

AcT = Pulmonary ejection acceleration time

AR = Aortic regurgitation

AS = Aortic stenosis

AVA = Aortic valve area

EROA = Effective regurgitant orifice area

IVC = Inferior vena cava

LV = Left ventricle

MR = Mitral regurgitation

PE = Pulmonary embolism

RV = Right ventricle

RVD = Right ventricular dysfunction

TES = Typical echocardiographic signs of acute pulmonary embolism

TR = Tricuspid valve regurgitation

TRPG = Tricuspid regurgitation peak systolic gradient

TTE = Transthoracic echocardiography

VC = Vena contracta

other coexisting heart abnormalities that can potentially explain acute signs and symptoms of PE, the detection of such abnormalities may postpone diagnostic PE workup or even lead to PE's being overlooked, especially when the clinical probability of this disease is rated as low. According to our knowledge, no comprehensive analysis has been published in which the investigators described echocardiographic findings that are typical of PE in a large group of patients with documented PE. In addition, it is important to note that in some cases, incidental echocardiographic findings can suggest alternative reasons for a patient's signs and symptoms, even though the patient has also experienced acute PE. Therefore, we aimed to assess the frequency of RVD, TES, and potentially incidental echocardiographic abnormalities in unselected consecutive patients with proven symptomatic acute PE.

METHODS

This was a retrospective analysis of 511 consecutive patients with confirmed symptomatic acute PE managed in our department between 2007 and 2015. The diagnosis of PE was confirmed when thromboemboli were visualized in an at least segmental pulmonary artery on contrast-enhanced multidetector computed tomography. Acute PE was diagnosed when symptoms suggestive of PE had been present for no longer than 14 days before the diagnosis. Patients with established chronic thromboembolic hypertension were excluded from this study.

Hemodynamic instability was defined according the European Society of Cardiology as systemic systolic blood pressure <90 mm Hg or a need for vasopressors without other coexisting causes such as hypovolemia or sepsis.[1] Patients with systemic systolic blood pressure of ≥90 mmHg who showed no signs of peripheral hypoperfusion were regarded as hemodynamically stable. An analysis of the prognostic value of echocardiographic parameters in a subgroup of this population has been published previously.[3]

Echocardiography

Standardized TTE focused on the assessment of the right ventricle and left heart valve function was performed and interpreted according to a previously described protocol by an experienced physician using a Philips iE33 or Philips HD11XE system (Philips Medical Systems, Andover, MA),[3] as soon as possible after admission, preferably within the first 24 hours. The examinations were digitally recorded. LV and RV diameters were measured in the apical four-chamber view at the level of the mitral and tricuspid valve tips at end-diastole (defined by the electrocardiographic R wave).[9] RV enlargement was diagnosed when RV four-chamber basal diameter was >42 mm.[10] We assessed the presence of the McConnell sign or RV free wall hypokinesis.[5] Tricuspid annular plane systolic excursion was measured in the M-mode presentation.[10] Tricuspid valve regurgitation was assessed qualitatively (color Doppler), and TRPG was calculated by applying a simplified Bernoulli formula, using tricuspid regurgitant systolic flow peak velocity (continuous-wave Doppler). In the parasternal short-axis view, flattening of the interventricular septum was assessed qualitatively, and AcT was measured in the RV outflow tract, proximal to the pulmonary valve (pulsed-wave Doppler). Presence of the 60/60 sign with a midsystolic notch in the pulmonary outflow Doppler profile was determined.[6]

LV ejection fraction was measured using the modified biplane Simpson method.[9] Aortic and mitral valve morphology and function were evaluated.

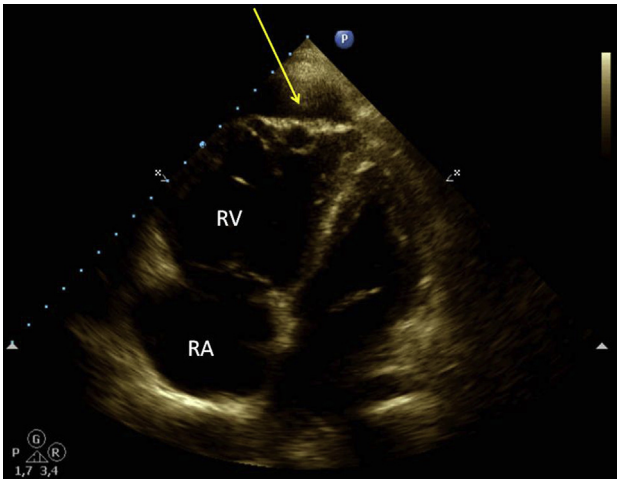

Figure 1 The McConnell sign. Hypokinesis of right ventricular free wall with a normal contraction of the apical segment *(arrow)*. *RA*, Right atrium; *RV*, right ventricle. Video 1 demonstrates McConnell sign with right ventricular free wall motion abnormalities.

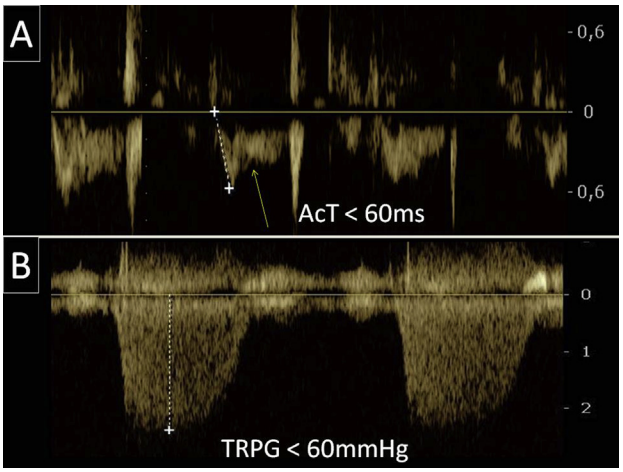

Figure 2 The 60/60 sign. Coexistence of shortened AcT < 60 msec **(A)** with midsystolic notch *(arrow)* and of TRPG < 60 mm Hg **(B)**.