The diagnostic value of three-dimensional echocardiography and speckle tracking echocardiography in patients after myocardial infarction with right ventricle involvement (clinical case)

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The inferior myocardial infarctions (MI) of left ventricle (LV) are often complicated with right ventricle (RV) involvement. The traditional echocardiographic parameters lack diagnostic accuracy in assessment of RV function. Speckle tracking echocardiography and three-dimensional echocardiography are promising diagnostic tools in quantification of RV.

The purpose of the study was to present the role of speckle tracking echocardiography and three-dimensional echocardiography in patients after inferior MI with RV involvement.

It was described a clinical case of a 67-year old male after recent inferior MI with RV involvement. The speckle tracking analysis and three-dimensional echocardiography was performed one and six months after coronary event. The initial study revealed decreased longitudinal strain of RV free wall segments, especially in the apical region. The RV global longitudinal strain was -8,8 % (normal range ≤ -20 %). The RV end-diastolic volume index was 100,9 ml/m² (normal range < 44 ml/m²) and RV end-systolic volume index was 69,8 ml/m² (normal range <44 ml/m²), indicating its severe enlargement. The three-dimensional RV ejection fraction (EF) was 31 % (normal range >45 %). The analysis on the sixth month revealed improvement of RV contractility in all segments with longitudinal strain of -14.2 %. The RV volumes decreased by 10 % and EF was raised from 31 to 33 %, reflecting positive cardiac remodeling during follow-up period.

Conclusions. Speckle tracking echocardiography and three-dimensional echocardiography provide additional diagnostic information in patients after MI with RV involvement and can be used for patients' follow-up.

Key words: three-dimensional echocardiography, speckle tracking echocardiography, infarction, right ventricle.
Описано клиническое наблюдение 67-летнего мужчины после недавнего ИМ нижней локализации с вовлечением ПЖ. Спекл-трекинг анализ и трехмерная эхокардиография проводили через 1 и 6 месяцев после коронарного события. Начальное исследование определило снижение продольного стрейна свободной стены ПЖ, особенно в апикальной зоне. Глобальный продольный стрейн ПЖ составил −8,8 % (норма ≤−20 %). Конечностистолический индекс ПЖ составил 100,9 ml/m² (норма <87 ml/m²), конечно-диастолический индекс — 69,8 ml/m², что свидетельствовало о его значительной дилатации. Трехмерная фракция выброса (ФВ) ПЖ составила 31 % (норма >45 %). Анализ через 6 месяцев определил улучшение сократимости всех сегментов ПЖ со значением глобального продольного стрейна -14,2 %. Объемы ПЖ уменьшились на 10 %, а ФВ увеличилась с 31 % до 33 %, отражая положительное ремоделирование сердца за период наблюдения.

Выводы. Спекл-трекинг эхокардиография и трехмерная эхокардиография имеют дополнительную диагностическую информативность у пациентов после перенесенного ИМ с вовлечением ПЖ и могут использоваться для динамического наблюдения.

The signs of right ventricle (RV) involvement are present in up to 40 % of patients with inferior myocardial infarction (MI) [1]. However, the diagnosis of right ventricle (RV) infarction is a challenging task. The use of additional right precordial leads (V₅R and V₆R) should be considered to identify concomitant RV infarction according to the 2017 European Society of Cardiology (ESC) guidelines on acute MI in patients presenting with ST-segment elevation [2]. Despite these recommendations, the RV acute ischemia often remains underdiagnosed in a real clinical practice.

Another important issue is the echocardiographic evaluation of RV systolic function. The 2015 guidelines for cardiac chamber quantification by echocardiography suggest using at least one or a combination of several parameters for RV function assessment (Table 1) [3]. Most of these parameters reflect only longitudinal contractility that can lead to inappropriate assessment of RV condition. Moreover, it is impossible to perform volumetric measurements and to calculate ejection fraction (EF) using two-dimensional echocardiography. The explanation is that no geometric assumption can be made for RV due to its complex structure.

Advanced ultrasound techniques might overcome these limitations. It is mentioned in the guidelines, that 3D-echo cardiography-derived RV EF should be considered as a method of quantifying RV systolic function in laboratories with appropriate 3D platforms and experience [3]. Speckle tracking echocardiography might be another useful technique, which allows to quantify global and regional RV contractility.

The purpose

The purpose of the study was to present the role of speckle tracking echocardiography and three-dimensional echocardiography in patient with inferior MI and RV involvement.

Clinical case presentation

67-year old male was admitted to the catheterization laboratory of Zaporizhzhia Regional Center of Cardiovascular Diseases with severe chest pain, lasting for 6 hours. His ECG showed ST elevation in II, III, aVF leads up to 10 mm and V₅R − V₆R right precordial leads up to 4 mm. Urgent coronary angiography revealed proximal right coronary artery occlusion, which was successfully treated with bare metal stent. His past medical history was positive for arterial hypertension and gout for 15 years. The patient was treated with valsartan 160 mg, bisoprolol 5 mg and allopurinol 200 mg before admission.

The early rehabilitation period passed without significant complications. The patient was examined twice – on the first and the sixth month after coronary event in the University Clinic of Zaporizhzhia State Medical University. His clinical condition was stable. The patient didn’t suffer from heart attacks. His ECG showed pathological Q-waves in II, III, aVF, V₅R, V₆R and V₆R (Fig. 1).

The conventional echocardiography was performed on Vivid E9 XD Clear (GE Vingmed Ultrasound, Horten, Norway) equipped with matrix phased array probe M5Sc. The main findings of the examination included increased left ventricle (LV) wall thickness and enlarged left atrium volume index. The LV EF was 52 % by Simpson method. The wall motion abnormalities consisted of basal septal, basal inferior and medium basal hypokinesia. The LV global longitudinal strain was -15.2 % (normal range ≤-20 %). The basal RV diameter was 5.2 cm (normal range < 4.1 cm) and mid-cavity diameter was 4.9 cm (normal range > 3.5 cm) in RV-focused apical view (Fig. 2). The conventional parameters of RV systolic function revealed preserved tricuspid annulus peak systolic excursion (16 mm) and pulsed tissue Doppler S wave (9 cm/s), whereas fractional area change was decreased (28 %).

The speckle tracking analysis was performed off-line with 2D Strain software on Echopac 113 work station (Gen-
eral Electric, USA). We used recently published consensus document on standardization of left atrial, right ventricular and right atrial deformation imaging using two-dimensional speckle tracking echocardiography [4]. This paper suggests using RV focused apical four-chamber view for image acquisition. Global RV longitudinal strain was reported as average of 6 segments of the RV free wall and the interventricular septum (Fig. 3).

The segmental values of RV free wall longitudinal strain were decreased, especially in the apical region (Table 2). The apical segment of the interventricular septum had positive strain, reflecting pathological systolic elongation due to tethering effect of the adjustment segments. The RV global longitudinal strain was – 8.8 % (normal range ≤ -20 %). The strain analysis on the sixth month revealed improvement in the RV contractility in all segments with calculated global

![Fig. 1. Surface 12-lead ECG with right precordial leads (V1R-V6R). Description is in the text. Voltage – 10 mm/mV, speed – 50 mm/s.](image1)

![Fig. 2. The RV-focused apical view, end-diastolic frame. Two-dimensional standard echocardiography, gray scale mode.](image2)

![Fig. 3. The RV longitudinal strain analysis (the first month after MI).](image3)
The RV longitudinal strain analysis (the sixth month after MI).

Six-beat full-volume 3D data set was obtained during breathhold using Vivid E9 (GE Vingmed Ultrasound, Horten, Norway) equipped with 4V probe. The calculation of RV volumes and EF was performed off-line using 4D RV-Function 1.2 software package (TomTec Imaging Systems GmbH, Germany). The RV endocardium was manually traced in four-chamber, sagittal (short-axis), and coronal planes, at end-diastole and end-systole. The alignment of the three planes required manipulation by slicing, rotating, and angulating in any of these three displayed orthogonal planes using a combination of software controls. Manual corrections of the RV contours were performed. The trabecular layer of the RV wall, papillary muscles, and moderator band were included in the RV cavity [5].

Longitudinal strain of – 14.2 % (normal range ≤ -20 %) (Fig. 4).

ESV: end-systolic volume; EDV: end-diastolic volume; EF: ejection fraction, SV: stroke volume.

Fig. 6. The generated 3D surface model of the RV, end-systolic frame. The fish-net white contour indicates end-diastolic frame. The longitudinal contractility remains preserved (white arrow), whereas radial contraction of RV free wall is severely decreased (red arrows).
The RV end-diastolic and end-systolic volumes were 211.9 and 146 ml, respectively (Fig. 5). It is recommended to use parameters, indexed to body surface area (BSA) [3]. The RV end-diastolic volume index was 100.9 ml/m² (normal range <87 ml/m²) and RV end-systolic volume index was 69.8 ml/m² (normal range <44 ml/m²), indicating its enlargement. The RV EF was 31 %. Roughly, an RV EF of <45 % usually reflects abnormal RV systolic function, though some laboratories use age- and gender-specific values.

The analysis of generated 3D surface model revealed that longitudinal contractility was preserved, so the reduction in RV EF was mainly influenced by radial component of contractility (Fig. 6). The RV end-diastolic volume index decreased to 91.3 ml/m² and RV end-systolic volume index to 61.1 ml/m² with calculated EF about 33 % during the follow-up period. It indicates some degree of RV recovery after myocardial infarction. It's worth mentioning, that both speckle tracking and three-dimensional echocardiography demonstrated these positive trends of RV remodeling.

**Discussion**

The RV infarction is often underdiagnosed despite its frequent association with inferior-wall MI [6]. The presence of RV involvement leads to unfavorable prognosis. Recent meta-analysis compared the in-hospital mortality in patients with RV involvement in fibrinolytic and mechanical reperfusion era [7]. It was shown that the presence of the RV infarction leads to 3-fold higher risk of mortality despite new reperfusion technologies.

The two-dimensional echocardiography has some important limitations in the assessment of RV [8]. This cardiac chamber has a unique crescent shape and no geometrical assumption can be made. Therefore, it is impossible to calculate RV volumes using Simpson method. RV consists of three parts (inflow tract, apex and outflow tract), which can never be visualized in the same acoustic plane. There are several parameters for RV systolic function evaluation and there is no agreement, which of them is preferable.

Obviously, echocardiography should not delay the invasive treatment in patients with acute coronary syndrome with ST segment elevation. However, echocardiographic evaluation should be done in early perspective after primary percutaneous intervention. Speckle tracking echocardiography is a new promising technique, which might improve quantification of RV. Some studies confirmed the prognostic importance of this technology in patient with RV infarction. Particularly, Park S. J. et al. (2015) showed that RV global longitudinal strain had better sensitivity and specificity in prediction of major adverse cardiac events, than TAPSE and FAC [9]. Patients with strain value ≥ -15,5 % showed significantly lower 5-year survival rate. In the recent study RV free wall longitudinal strain ≥ -22 % was an important predictor of malignant arrhythmias independent of LV function in patients after acute MI [10].

Three-dimensional echocardiography could be another important diagnostic tool for RV assessment. It is the only technique, besides magnetic resonance imaging, which allows to calculate RV volumes and EF. There is a lack of prospective data confirming the prognostic role of this diagnostic modality. However, the previous studies with cardiac magnetic resonance estimated that RVEF <40 % was strongly associated with mortality [11, 12]. Considering good agreement between two methods, 3D echocardiography may potentially become the first-choice diagnostic tool for assessment of RV volumes and EF [5].

To sum up, the main finding of presented clinical case is significant RV injury in patient with inferior MI, despite preserved LV EF, which was diagnosed by new ultrasound imaging modalities. Speckle tracking echocardiography and three-dimensional echocardiography improve diagnostic accuracy in field of quantitative assessment of the RV ischemic damage.

**Conclusions**

The standard echocardiographic parameters of the RV quantification lack diagnostic accuracy in patients after MI with the RV involvement. Speckle tracking echocardiography and three-dimensional echocardiography provide additional diagnostic and prognostic information in patients after acute myocardial ischemia with the RV involvement. These diagnostic modalities can be used for patients' follow-up to assess cardiac remodeling process.

**Prospects for further research.** It is planned to work out the criteria of positive and negative remodeling of the RV after MI using speckle tracking echocardiography and three-dimensional echocardiography.

**Conflicts of interest:** author has no conflict of interest to declare.

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