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Application of volume rendering for evaluation of right ventricle dysfunction in patients with acute pulmonary embolism diagnosed with multislice computed tomography pulmonary angiography (MSCTPA)

MSCT becomes accepted imaging modality of choice in patients with suspected pulmonary embolism (PE). Increasing availability and continuous improvement of computed tomography, as well as the opportunity of making additional diagnoses, resulted in raising interest in CT pulmonary angiography (1).

Right ventricle dysfunction (RVD) may result from acute PE. It results from increased pulmonary artery pressure and afterload of the right ventricle, which causes dilatation and dysfunction of the right ventricle. Such condition may cause a decreased left ventricular preload and output, which leads to hypotension and decreased coronary perfusion. Hemodynamic decompensation, however, results not only from pulmonary arteries obstruction, but also from the body reaction with multiple humoral factors, like serotonin, thrombin and histamine (2).

Evaluation of PE severity and RVD determine the choice of location of therapy – original department, department of cardiology or pulmonology, as well as algorithm of therapy (3) and prognosis (4).

The purpose of the study was to evaluate usefulness of volumetric reconstructions of ventricles in MSCT pulmonary angiography (MSCTPA) for assessment of RVD in patients with acute PE.

MATERIAL AND METHODS

35 patients with MSCTPA diagnosis of acute PE (8- and 64-row LightSpeed scanner with 0.6 mm collimation) were included into the study. Mean age was 60.32±14.22 years, male: female ratio: 19:16. Patients with history of valvular disease, coronary disease and myocardial infarction, cardiac arrhythmias, COPD, interstitial lung diseases and previous PE episode were not included in the study group. Quantification of pulmonary arteries obstruction was performed according to Mastora et al. score (5). All patients had echocardiographic evaluation of pulmonary artery systolic pressure (PASP) performed within 2 hrs from CT examination, and were divided into groups with normal (group N, PASP $\leq$ 30 mmHg)

and increased PASP (group I. PASP > 30 mmHg). No significant differences of gender distribution and age were observed between study groups. The following parameters of RVD were evaluated in CT examinations: left ventricle short axis (LV_L), right ventricle short axis (RV_L), and RV/LV_L ratio, evaluated in four-chamber view (Fig. 1a), as well as volume of the left ventricle (LV_V), right ventricle (RV_V) and ventricular volumes ratio (RV/LV_V) reconstructed with Volume Rendering application (Fig. 1b).

Differences between groups with normal and increased PASP were checked with Mann-Whitney test. Values of $p \leq 0.05$ were considered significant. Specificity, sensitivity and predictive values of the parameters for the presence of increased PASP were evaluated. Cutoff values with best sensitivity and specificity ratio were calculated.

RESULTS

Median values of PASP were significantly different ($p < 0.001$) between groups with normal and increased PASP (25 mmHg and 42 mmHg, respectively). Mastora et al. score in group I was significantly higher (37.4%) than in group N (12.6%). Values of heart parameters and statistical analysis are presented in Figure 1c–1f.

Fig. 1a. RV_L and LV_L measurement on four-chamber view

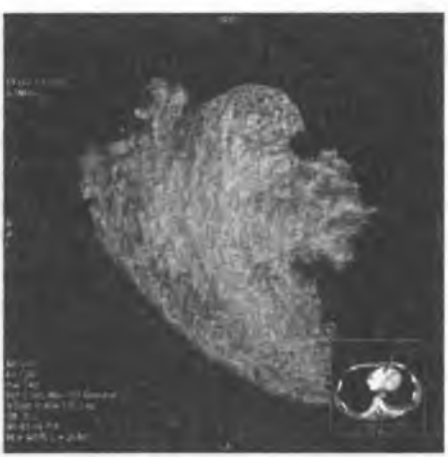

Fig. 1b. RV_V reconstruction with Volume Rendering application

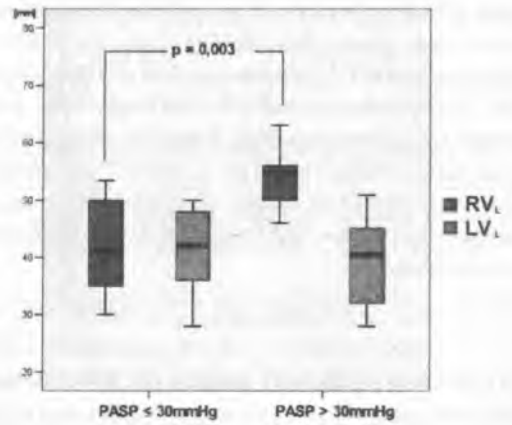

Fig. 1c. RV_L and LV_L values and statistical analysis

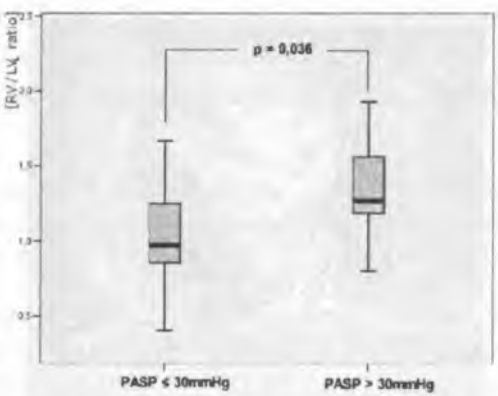

Fig. 1d. RV/LV_L values and statistical analysis

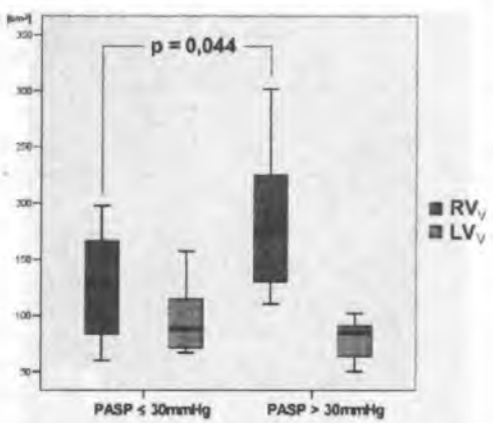

Fig. 1e. RV_V and LV_V values and statistical analysis

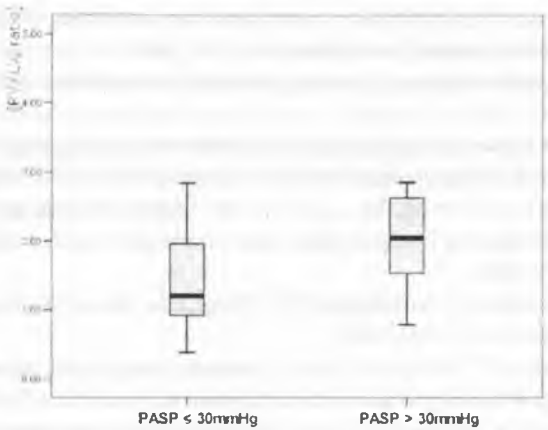

Fig. 1f. RV/LV_V values, no statistical difference between groups

Sensitivity (S), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV) were evaluated for the significantly different parameters. The cutoff values were measured by selecting best sensitivity and specificity ratio, and were as follows: $RV_L > 50$ mm, $RV/LV_L > 1.3$, $RV_V > 130$ cm^3. RV_L was characterized by S = 0.8; Sp = 0.77; PPV = 0.73; NPV = 0.83; RV/LV_L: S = 0.64; Sp = 0.69; PPV = 0.6; NPV = 0.69; RV_V: S = 0.67; Sp = 0.64; PPV = 0.6; NPV = 0.73.

DISCUSSION

Identification of PE and RVD in its course is of very high clinical importance. Diagnostic methods used in computed tomography: physical exam, chest x-ray, V/Q scan, biomarkers (6) do not allow a reliable identification of patients with RVD. Typically, ECG and echocardiography are performed to assess the right ventricle function in the course of PE. Recently, heart parameters evaluated in the MSCTPA became a promising RVD indicator (7). The aim of the study was to evaluate feasibility of volumetric reconstructions in CT examination for assessment of RVD in the course of PE.

Linear parameters of heart ventricles are a recognized indicator of RVD (8). RV/LV_L ratio > 0.9 is considered as predictor of complications in the course of PE (9), and value > 2.3 is related with up to 50% 3-months' mortality (10). This corresponds to the results of the own study, which showed RV_L and RV/LV_L to be significantly higher in group I.

Among the volumetric parameters of the right and left ventricle, only RV_L was significantly different between the groups. Moreover, all test parameters: S, Sp, PPV and NPV were lower than those of linear parameters: RV_L and RV/LV_L. When combined with a long time required for performing volumetric reconstruction of heart ventricles, the feasibility of volume rendering application in RVD is apparently limited. The results of the study indicate that application of volume rendering for reconstruction of ventricular volumes in MSCTPA does not improve assessment of RVD in patients with acute PE.

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SUMMARY

The purpose of the study was to evaluate usefulness of volumetric reconstructions of ventricles in MSCT pulmonary angiography (MSCTPA) for assessment of RVD in patients with acute pulmonary embolism (PE). 35 patients with MSCTPA diagnosis of acute PE were included into the study. Quantification of pulmonary arteries obstruction was performed according to Mastora score. All patients had echocardiographic evaluation of pulmonary artery systolic pressure (PASP) performed, and were divided into groups with normal and increased PASP. Evaluation of RVD was performed with the following parameters: left ventricle (LV) short axis, right ventricle (RV) short axis, and RV/LV ratio, as well as LV volume, RV volume and RV/LV volume ratio. Short axis diameter of RV, and RV/LV ratio were significantly higher in patients with increased PASP. Among volumetric measurements, only RV volume differed significantly between groups. Both sensitivity and specificity of the volumetric measurements were lower than linear ones. The results of the study indicate that application of volume rendering in MSCTPA does not improve assessment of RVD in patients with acute pulmonary embolism.

Zastosowanie rekonstrukcji objętościowych do oceny przeciążenia prawej komory serca u pacjentów z ostrą zatorowością płucną diagnozowanych w wielorzędowej tomografii komputerowej

Celem pracy było zbadanie przydatności rekonstrukcji objętościowych komór serca do oceny przeciążenia prawej komory w angiografii płucnej wielorzędowej tomografii komputerowej. Zbadano pięciu pacjentów z potwierdzoną ostrą zatorowością płucną w badaniu TK. Ocena nasilenia zmian zatorowych przeprowadzona została przy pomocy skali Mastory. U wszystkich pacjentów przeprowadzono echokardiograficzną ocenę ciśnienia w pniu płucnym (PASP), na podstawie której wydzielono grupy z prawidłowym i podwyższonym PASP. Do oceny przeciążenia prawej

komory zastosowano wymiary liniowe prawej i lewej komory i ich stosunek, oraz oszacowaną w rekonstrukcjach Volume Rendering objętość prawej i lewej komory i ich stosunek. W grupie z podwyższonym PASP stwierdzono występowanie istotnie wyższych wartości pomiarów liniowych prawej komory i stosunku komór oraz objętości prawej komory. Czułość i specyficzność pomiarów objętościowych była niższa niż pomiarów liniowych. Zastosowanie rekonstrukcji objętościowych komór serca nie wpływa na polepszenie możliwości identyfikacji pacjentów z podwyższonym PASP w przebiegu ostrej zatorowości płucnej.