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# Prediction of right ventricular dysfunction from radiographic estimates of right descending pulmonary artery in hemodynamically stable pulmonary embolism patients

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## Abstract

**Background:** *The evaluation of right ventricular (RV) dysfunction by echocardiography is one of the most important established determinants of the prognosis of acute pulmonary embolism. The aim of the study was to investigate possible association between diameter of right descending pulmonary artery on chest X-rays and RV dysfunction by echocardiography in hemodynamically stable pulmonary embolism patients.*

**Methods:** *Eighty-nine patients with the diagnosis of hemodynamically stable pulmonary embolism were included.*

**Results:** *The frequency of RV dysfunction was significantly higher in patients with an enlarged right descending pulmonary artery on chest X-rays ($p = 0.001$). There was a significant positive correlation between the diameter of the right descending pulmonary artery on postero-anterior chest X-rays and the diameter of the RV ($r = 0.469$; $p = 0.002$). Diameter of right descending pulmonary artery on chest X-rays was also found as a significant predictor of RV dysfunction besides the troponin-T levels and systolic pulmonary arterial pressure ($p < 0.05$).*

**Conclusions:** *Diameter of right descending pulmonary artery on chest X-rays may provide information about the risk for pulmonary embolism patients and may be used as a prognostic radiological parameter for the appropriate management of acute pulmonary embolism.* (Cardiol J 2013; 20, 2: 184–189)

**Key words: pulmonary embolism, right ventricular dysfunction**

## Introduction

The evaluation of right ventricular (RV) dysfunction by echocardiography is one of the most important established determinants of the prognosis of acute pulmonary embolism (PE) [1, 2]. Mortality has been known to be high in patients with RV dysfunction at presentation [3]. However echocardiography is a user-dependent procedure and is not always readily available for a diagnostic

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workup and risk stratification of PE. Recently many markers including cardiac troponin I or T [4, 5], N-terminal pro-BNP (NT-proBNP) [6], B-type natriuretic peptide (BNP) [7], the plasma heart-type fatty acid binding protein [8], growth differentiation factor (GDF)-15 [9] and the C-reactive protein [10] have been shown to be associated with an increased risk of complications and death in patients suffering acute PE. These markers have also been shown to be associated with RV dysfunction which is a gold standard measure of the prognosis for PE patients. However these biomarkers may not be easily accessible in clinical settings due to the high expenditure involved or limited availability of them. Diagnostic methods that are easily applied and accessible are needed to determine RV dysfunction in PE for accurate and rapid risk stratification.

Radiographic abnormalities have been shown to be associated with PE [11–13]. Transient enlargement of right descending pulmonary artery in PE patients has been reported in various studies [12, 14–16]. Previous reports have shown a correlation between right descending pulmonary artery diameter and systolic pulmonary artery pressure estimated by echocardiography [17] and it has also been shown that a diagnosis of pulmonary hypertension can be derived from radiographic estimates of pulmonary arterial size [18]. An association between enlargement of the right descending pulmonary artery and RV hypokinesis has been previously studied but other RV parameters of dysfunction, including dilatation of the RV (diastolic diameter > 30 mm), abnormal motion of the interventricular septum, hypokinesis of the RV, or tricuspid valve regurgitation (jet velocity > 2.5 m/s) and their association with enlargement of the right descending pulmonary artery on chest X-rays have not been studied. We designed the present study in order to investigate the possible prediction of RV dysfunction from radiographic estimates of right descending pulmonary artery in PE patients.

## Methods

The investigation conforms to the principles outlined in the Declaration of Helsinki. The study was a retrospective chart review approved by the local ethics committee. All the radiological images and echocardiographical measurements were obtained from the hospital database sysytem. Eighty-nine patients with a diagnosis of hemodynamically stable PE were included (M:F = 41/48; age 65 ± 13.5) in the study. PE patients without having RV echocardiographic measurements within 24 h of admission were not included into the study. PE patients with techinical difficulties about reading of postero-anterior (PA) chest X-rays were not included into the study. The patients with pre-existing severe heart failure or mitral valve regurgitation or right myocardial infarction and with pre-existing severe chronic obstructive pulmonary disease interfering both RV echocardiographic measurements and right descending pulmonary artery on chest X-rays were also not included into the study population. Diameter of right descending pulmonary artery on PA chest X-ray on admission was measured by a at least two physician trained by a expert radiologist for the measurement of right descending pulmonary artery on PA chest X-ray. Physicians measuring diameter of right descending pulmonary artery on PA chest X-ray on admission were blinded to the result of measurement for RV dysfunction on echocardiography.

The diagnosis of PE was made by using spiral computerized tomography-angiography or a ventilation-perfusion scan with clinical probability score in all patients. The RV function was evaluated by conventional transthoracic echocardiography and RV dysfunction was defined if at least one of the following was present: 1 — dilatation of the RV (diastolic diameter > 30 mm), 2 — abnormal motion of the interventricular septum, 3 — hypokinesis of RV, or 4 — tricuspid valve regurgitation (jet velocity > 2.5 m/s) [19].

Chest X-ray films (standard PA view) of each subject were taken on admission to the hospital with the diagnosis of PE. The diameter of the right descending pulmonary artery on PA chest X-ray was measured according to previously reported methods [20, 21] defining the normal upper limit as 15 mm for females and 16 mm for males (Fig. 1). If this measure was 16 mm or greater, or 17 mm or greater, for females and males respectively, the right descending pulmonary artery was defined as enlarged.

Patients who had been diagnosed with PE received standard anticoagulant treatment which was either low molecular weight heparin (LMWH, particularly enoxaparin: 100 IU/kg twice daily) or standart unfractionated heparin which is a bolus of 80 U/kg followed by a continuous infusion of 18 U/kg/h and targeting activated partial thromboplastin time by a factor of 1.5–2.5. Warfarin was given for a period of at least 3 months with the aim of, reaching an international normalized ratio (INR) of 2.0–3.0 during follow-up.

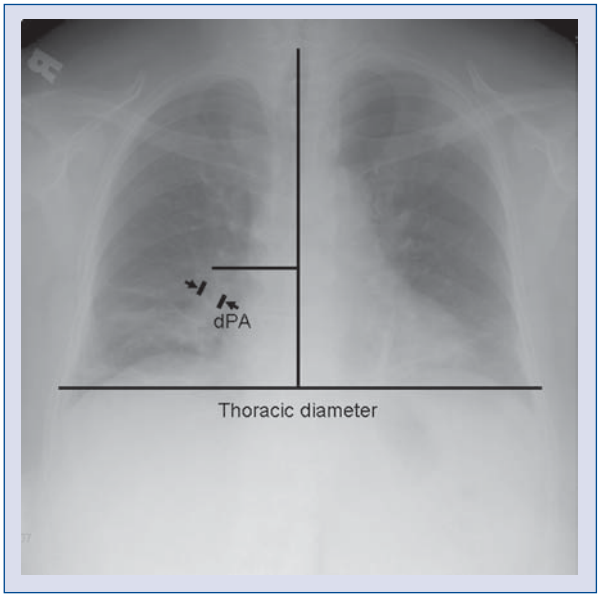


**Figure 1.** Sites of measurement right descending pulmonary artery (dPA).

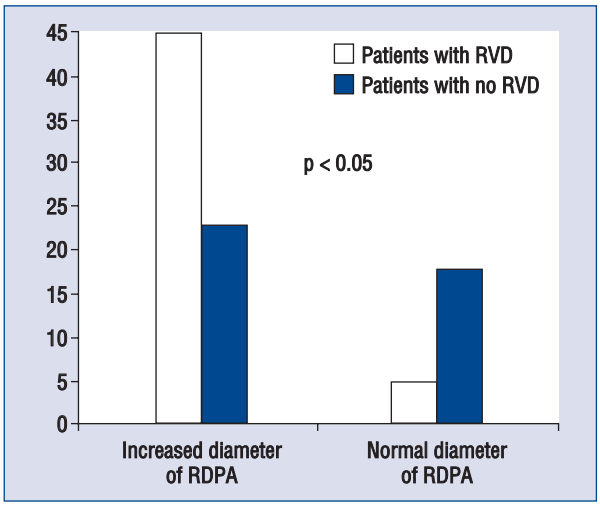


**Figure 2.** Increased frequency of right ventricular dysfunction (RVD) in hemodynamically stable pulmonary embolism patients with an enlarged right descending pulmonary artery (RDPA) on chest X-rays.

## Statistical analysis

The statistical analysis was made with the use of a commercially available statistical package SPSS for Windows, Version 15.0. Continuous variables were expressed as mean ± standard deviation while categorical variables were expressed as ratios. Categorical and discrete variables were compared using the $\chi^2$ test. A receiver operating characteristic curve was used to find an optimal cut-off point of diameter of right descending pulmonary artery on chest X-rays for predicting RV dysfunction in PE patients. A Pearson correlation analysis was made to investigate the possible association between RV dysfunction and diameter of right descending pulmonary artery on chest X-rays. Linear regression analysis was used for defining predictors of RV dysfunction. Probability values of $< 0.05$ were considered significant.

## Results

A total of 89 subjects were enrolled in this study. The mean age of the patients was 65 ± ± 13.5 years with 41 male patients. Fifty (56.2%) of the PE patients had RV dysfunction. The frequency of RV dysfunction was significantly higher in patients with an enlarged right descending pulmonary artery on chest X-rays ($p = = 0.001$) (Fig. 2, Table 1). There was a significant positive correlation between the diameter of the right descending pulmonary artery on PA chest X-ray and both the RV diameter ($r = 0.469$; $p = = 0.002$) and the RV/LV ratio of end diastolic diameter ($r = 0.646$; $p < 0.001$) (Figs. 3, 4). An ROC analysis was used to identify the optimal cut-off value of right descending pulmonary artery diameter as measured on chest X-rays for the prediction of RV dysfunction of PE patients. The AUC was 0.76 for defining RV dysfunction on the basis of the diameter of the right descending pulmonary artery on chest X-rays with a sensitivity of 78% and a specificity 63% at the diameter of 16.25 mm (Fig. 5). When RV dysfunction was predicted it was found that diameter of the right descending pulmonary artery on chest X-rays (Beta = 0.26; $p = 0.024$), systolic pulmonary arterial pressure

**Table 1.** Presence of right ventricular dysfunction in hemodynamically stable pulmonary embolism patients with an enlarged right descending pulmonary artery on chest X-rays.

| Right ventricular dysfunction | Diameter of right descending pulmonary artery on chest-X-rays | |
|---|---|---|
| | Normal | Enlarged |
| Present | 5 | 45 |
| Absent | 18 | 21 |
| Total | 23 | 66 |

$\chi^2$: $p = 0.001$

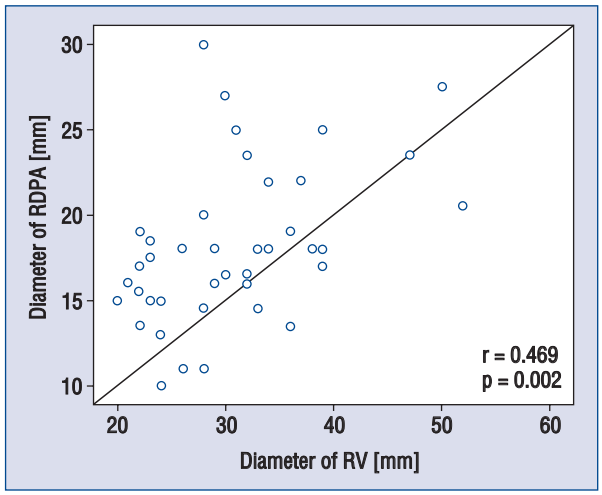


**Figure 3.** Correlation between diameter of right descending pulmonary artery (RDPA) on postero-anterior chest X-ray and right ventricular (RV) diameter on echocardiography.

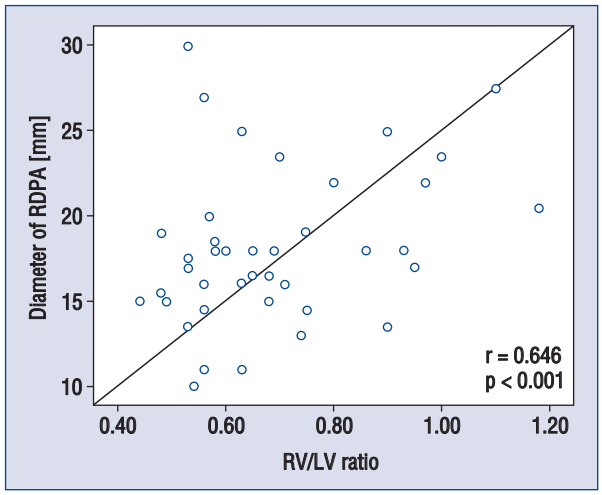


**Figure 4.** Correlation between diameter of right descending pulmonary artery (RDPA) on postero-anterior chest X-ray and right ventricular/left ventricular (RV/LV) ratio of end diastolic diameter on echocardiography.

on echocardiography (Beta = 0.48; p = 0.001) and troponin-T levels (Beta = 0.30; p = 0.012) were significant predictors with linear regression analysis (Table 2).

## Discussion

Risk stratification in hemodynamically stable PE has been gaining importance recently. RV dysfunction detected by echocardiography or by biomarkers including especially troponin-T, BNP and

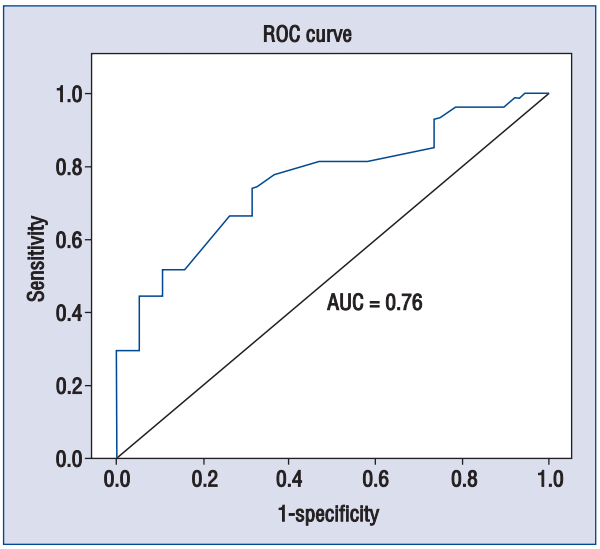


**Figure 5.** Receiver operating curve analysis to identify the optimal cut-off value of right descending pulmonary artery diameter on chest X-rays for the prediction of right ventricular dysfunction by echocardiography in hemodynamically stable pulmonary embolism patients.

**Table 2.** Predictors of right ventricular dysfunction in hemodynamically stable pulmonary embolism patients with linear regression analysis.

| Predictors of right ventricular dysfunction | Standardized coefficients Beta | P |
|---|---|---|
| Diameter of right descending pulmonary artery on chest-X-rays | 0.26 | 0.024 |
| Systolic pulmonary arterial pressure on echocardiography | 0.48 | 0.001 |
| Troponin-T levels | 0.30 | 0.012 |

NT-proBNP has been known to be associated with a poor prognosis in PE [6, 19, 22, 23]. However, echocardiography and these biomarkers are not always available to determine the prognosis in acute PE, especially in acute settings. Simple and easily applied parameters for identifying RV dysfunction in PE are needed. The present study showed that increased diameter of the right descending pulmonary artery on chest X-rays is a simple and easily applied measure that has a significant correlation with RV dysfunction on echocardiography in hemodynamically stable PE patients. Both RV diameter and the end-diastolic RV/LV ratio had a significant

association with the diameter of right descending pulmonary artery on chest X-rays. An enlarged right descending pulmonary artery was matched in patients with confirmed and unconfirmed PE and has been more frequently seen in embolic patients in literature [24]. Previously it has also been shown that there is an association between the diameter of the right descending pulmonary artery and pulmonary hypertension as revealed by right heart catheterization and by echocardiography [17, 25]. If the diameter of the right descending pulmonary artery as less than 14 mm was used as a cut-off value, it was found that the accuracy of diagnosis of the mean pulmonary arterial pressure as measured by right heart catheterization lower than 20 mm Hg was 69.23% [25]. With the cut-off point of the diameter of the right descending pulmonary artery as 21 mm it was shown that specificity for echocardiographic pulmonary hypertension was 97.9% [17]. Palla et al. [26] found that the radiographic width of the descending pulmonary artery enabled the clinician to identify patients most seriously ill, since it showed a positive linear correlation with the degree of perfusion impairment. The RV dysfunction with defined echocardiographical parameters has not been compared with the right descending pulmonary artery on chest X-rays previously. The present study showed that the diameter of right descending pulmonary artery on chest X-ray had a sensitivity of 78% and a spesificity of 63% at the diameter of 16.25 mm for defining echocardiograhic RV dysfunction in PE patients. The present study demonstrated that an increased diameter of the right descending pulmonary artery on chest X-ray in acute PE patients may predict echocardiographic RV dysfunction in these patients. An association between RV hypokinesis and right descending pulmonary artery has been studied previously and chest radiographs were interpreted to show pulmonary artery enlargement for 118 of 309 patients with RV hypokinesis (sensitivity, 0.38) and for 117 of 483 patients without RV hypokinesis (specificity, 0.76) [15]. However other parameters of RV dysfunction including dilatation of the RV (diastolic diameter > 30 mm), abnormal motion of the interventricular septum, tricuspid valve regurgitation (jet velocity > 2.5 m/s) and end diastolic RV/LV ratio other than RV hypokinesis were not studied to investigate the possible association between the diameter of the right descending pulmonary artery on chest X-rays with a defined cut-off point and RV dysfunction on echocardiography. Chest X-rays are already easily applied and performed in all emergency settings especially at the beginning of diagnosis of PE. Diameter of right descending pulmonary artery on chest X-rays was found as a significant predictor of RV dysfunction besides the commonly used troponin-T levels and systolic pulmonary arterial pressure in the present study. Therefore measurement of the diameter of the right descending pulmonary artery on chest X-ray can be a simple method for detecting echocardiographic RV dysfunction in PE patients. The changes in diameter of the right descending pulmonary artery in PE are known and these changes are attributed to the acute occlusion of some part of the pulmonary vascular bed, producing a rise of pulmonary vascular resistance and pressure [16, 27]. Increased pulmonary vascular resistance has a potential to be associated with RV dysfunction in PE [28]. Through all these mechanisms the changes in the diameter of right descending pulmonary artery may be indirectly associated with the RV dysfunction that is gold standard for the prognosis of PE. The present study has shown that RV dysfunction is more frequently seen in patients with an increased diameter of the right descending pulmonary artery on chest X-ray and that this was statistically significant.

## Limitations of the study

There are several certain limitations to the present study. The sample size of the present study is small because we did not include PE patients without having RV echocardiographic measurements within 24 h of admission into the study. PE patients with technical difficulties about reading of PA chest X-rays were not also included into the study which was another reason for the small sample size. Secondly, this is not a follow-up study to compare the mortality or re-embolism of PE patients who had an enlarged diameter of the right descending pulmonary artery on chest X rays. Thirdly, we did not exactly know whether chest X rays were performed in the upright or in the supine position for the standardization due to retrospective feature of the study.

## Conclusions

In conclusion, hemodynamically stable PE patients with greater diameter of the right descending pulmonary artery on chest X-rays have more frequent RV dysfunction. There is a correlation between RV dysfunction parameters on echocardiography and the diameter of the right descending pulmonary artery on chest X-rays in hemodynamically stable PE patients. The suggested cut-off point of

the diameter of the right descending pulmonary artery on chest X-rays is 16.25 to predict RV dysfunction in hemodynamically stable PE patients. Diameter of right descending pulmonary artery on chest X-rays may be used as a predictor of RV dysfunction besides the commonly used troponin-T levels and systolic pulmonary arterial pressure. The diameter of the right descending pulmonary artery on chest X-rays may help in the risk stratification of hemodynamically stable PE patients and may be used as a prognostic tool for the appropriate therapeutic management of acute PE as being an easily applicable radiological parameter.

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## Author contributions

*Dr Abul:* Contributed to study concept and design, acquisition of data, analysis and interpretation of data, statistical analysis, critical revision of the manuscript for important intellectual content, and drafting of the manuscript; *Dr Ozsu:* Contributed to study concept and design, acquisition of data, analysis and interpretation of data, statistical analysis, critical revision of the manuscript for important intellectual content, and drafting of the manuscript; *Dr Karakurt*: Analysis of the results, and interpretation of data; *Dr Ozben:* Collection of data and interpretation of data; *Dr Durmus:* Collection of data and interpretation of data; *Dr. Toprak:* Interpretation of data; *Dr Ozlu:* Coordination of the study, interpretation of the study; *Dr Celikel:* Interpretation of the study and review before publication.

**Conflict of interest:** none to declare

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