



# Measurement of pulmonary artery to aorta ratio in computed tomography is correlated with pulmonary artery pressure in critically ill chronic obstructive pulmonary disease patients<sup>☆,☆☆</sup>



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## ABSTRACT

**Aim:** Chronic obstructive pulmonary disease (COPD) is one of the leading chronic diseases and a common cause of death. Identification of COPD patients at high risk for complications and mortality is of utmost importance. Computed tomography (CT) can be used to measure the ratio of the diameter of the pulmonary artery (PA) to the diameter of the aorta (A), and PA/A ratio was shown to be correlated with PA pressure (PAP). However, the prognostic value of PA size remains unclear in patients with COPD. We hypothesized that PA enlargement, as shown by a PA/A ratio greater than 1, could be associated with a higher risk of mortality in COPD patients admitted to the intensive care unit.

**Methods:** Data of patients admitted to a medical intensive care unit of a university hospital were retrospectively reviewed between January 2008 and December 2012. Patients who were identified to have a diagnosis of acute exacerbation of COPD and who had an echocardiogram and CT scan were included. Pulmonary artery to aorta ratio was calculated and patients were grouped as PA/A  $\leq 1$  and PA/A  $> 1$ . Comparisons were made between the groups and between patients who died and survived. Correlation analysis, survival analysis, and logistic regression analysis were done, where appropriate.

**Results:** One hundred six COPD patients were enrolled. There were 40 (37.4%) patients who had a PA/A  $> 1$ . Echocardiography measured PAP was higher in the group with PA/A  $> 1$  than in those with PA/A  $\leq 1$  ( $62.1 \pm 23.2$  mm Hg vs  $45.3 \pm 17.9$  mm Hg,  $P = .002$ ). Mortality rate of patients with PA/A  $> 1$  was higher (50%) than of those patients with PA/A  $\leq 1$  (36.4%), although the difference did not reach a statistical significance ( $P = .17$ ). Correlation was found between measured PA diameter and PAP ( $r = 0.51$ ,  $P = .001$ ) as well as between the Acute Physiology and Chronic Health Evaluation II values and PAP ( $r = 0.25$ ,  $P = .025$ ).

**Conclusion:** The PA/A ratio is an easily measured method that can be performed on thorax CT scans. Although, we failed to demonstrate a statistically significant association between higher PA/A and increased mortality, PA/A can be used as a surrogate marker to predict the pulmonary hypertension.

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## 1. Introduction

Chronic obstructive pulmonary disease (COPD) is one of the leading chronic diseases in the world as well as in Turkey and is an increasingly common cause of death [1,2]. In advanced stages of the disease, episodes of acute respiratory failure may require intensive care unit (ICU) admission [3]. Although the corresponding acute mortality is usually lower than that of other diseases, each exacerbation is associated with

decreased pulmonary functional reserve [4–6]. Of note, intubation and invasive mechanical ventilation during an episode of exacerbation are associated with longer durations of stay and increased in-hospital and out-of-hospital mortality rates [7–9]. Identification of COPD patients at high risk for complications and mortality is of utmost importance. Severe pulmonary hypertension may develop as an important complication of advanced COPD, although it may also complicate COPD at early stages of the disease. Pulmonary vascular disease reflected as pulmonary hypertension may predict the frequency of acute exacerbations and risk of death [10–12].

Computed tomography (CT) is a noninvasive, valuable tool in the evaluation of intrathoracic vasculature in patients with COPD. It can be used to measure the diameter of the pulmonary artery (PA), and the ratio of the diameter of the PA to the diameter of the aorta (A; PA/A ratio) was shown to be correlated with PA pressure (PAP) [13–15].

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However, the prognostic value of PA size remains unclear in patients with COPD. There is no study evaluating the association of PA/A ratio and mortality in COPD patients with acute exacerbation admitted to the ICU. We hypothesized that PA enlargement, as shown by PA/A ratio  $>1$ , could be associated with a higher risk of mortality in COPD patients admitted to the ICU with acute exacerbation.

## 2. Materials and methods

The study was done in the medical ICU of a tertiary care university hospital in Turkey. Data of all patients admitted to the medical ICU between January 2008 and December 2012 were retrospectively reviewed. Clinical and laboratory data were retrieved from patient medical records. Patients who were admitted to the ICU with a diagnosis of acute exacerbation of COPD were identified based on *International Diagnosis of Diseases, 10th Revision* codes and patient medical files. Patients who were identified to have a diagnosis of acute exacerbation of COPD and who had a CT scan performed within the 6 months were enrolled for analysis. Patients with concomitant pulmonary embolism were excluded.

Age and sex of the patients, admission Acute Physiology and Chronic Health Evaluation (APACHE) II scores, echocardiographic results as PAP and ejection fraction (EF), partial arterial oxygen pressure, partial arterial carbon dioxide pressure, CT calculation of aorta and PA diameter, application of invasive and noninvasive mechanical ventilation (NIMV), length of ICU stay, and ICU mortality rate were recorded. One thoracic radiologist who was blind to the clinical data of the patients reanalyzed the CT scans and performed the measurements. The PA and ascending aorta (A) diameters were measured transversely on CT scans at the level of main PA bifurcation (Fig. 1) [13]. Ratio of the diameter of the PA to the diameter of A (PA/A ratio) was calculated and patients were grouped as PA/A  $\leq 1$  and PA/A  $>1$ .

Baseline data of the patients were expressed as mean  $\pm$  SD for normally distributed values. Continuous variables were compared using Student *t* test, and categorical variables were compared by  $\chi^2$  and Fisher exact test, where appropriate. Pearson correlation coefficient was determined for the relationship between the PA diameter and PAP and between APACHE II and PAP. Survival analysis was performed by Kaplan-Meier curve, and significance was assigned with log-rank test. All statistical tests were 2 sided, with significance assigned to tests with *P* values less than .05. Logistic regression analysis was used to determine independent

risk factors for mortality by using variables, which influenced mortality in bivariate analysis with a *P* value less than .20. Area under the curve (AUC) was determined by receiver operating curve (ROC).

## 3. Results

A total of 471 patient records were reviewed. Of these, 106 patients (22.5%) had a diagnosis of COPD with acute exacerbation and had a CT scan performed before and during the index admission. Seventy-six patients had an echocardiography performed. General characteristics of the patients are shown in Table 1. Forty (37.7%) patients had PA/A  $>1$  and 66 (62.3%) patients had PA/A  $\leq 1$ . Among 76 patients included for further analysis, 27 (35.5%) had PA/A ratio  $>1$  and 49 (64.5%) had a PA/A ratio  $\leq 1$ . In the PA/A  $>1$  group, PAP was higher than the other group (*P* = .002). There was no difference between groups with regard to mean EF (*P* = .335). Echocardiography-measured mean PAP was higher in the group with PA/A  $>1$  than in those with PA/A  $\leq 1$  ( $62.14 \pm 23.17$  mm Hg vs  $45.32 \pm 17.9$  mm Hg, *P* = .002). There was a correlation between CT scan-measured PA diameter and PAP (*r* = 0.51, *P* = .001). Patients with higher APACHE II scores had higher PAPs (*r* = 0.25, *P* = .025; Fig. 2).

General characteristics and comparison of patients who survived and died in ICU are shown in Table 2. Mortality was higher in patients with PA/A ratio  $>1$  than in patients with PA/A  $\leq 1$ , but there was no statistical significance (*P* = .26). In multivariate (logistic regression) analysis, none of the factors showed a significant effect on ICU survival. Fig. 3 demonstrates the survival analysis of patients with COPD according to the PA/A ratio group. There was no difference in survival of patients with PA/A  $>1$  and with PA/A  $\leq 1$  (*P* = .265).

We tested the sensitivity and the specificity of the PA diameter and the PAP in predicting the mortality by ROC analysis. In ROC analysis, PA diameter had a sensitivity of 33.3% (95% confidence interval [CI], 13.8–50.2), a specificity of 79.6% (95% CI, 70.3–92.7), and cutoff value of 40 mm, whereas PAP had a sensitivity of 33.3% (95% CI, 16.5–54), a specificity of 83.7% (95% CI, 70.3–92.7), and cutoff value of 66 mm Hg for prediction of mortality (AUC, 0.530 and 0.544, respectively).

The cutoff value of PA diameter was 28 mm, which predicted pulmonary hypertension with a sensitivity of 89.2% (95% CI, 79.1–95.1) and a specificity of 54.5% (95% CI, 23.4–83.3 AUC, 0.678; 95% CI, 0.561–0.780; *P* = .104).

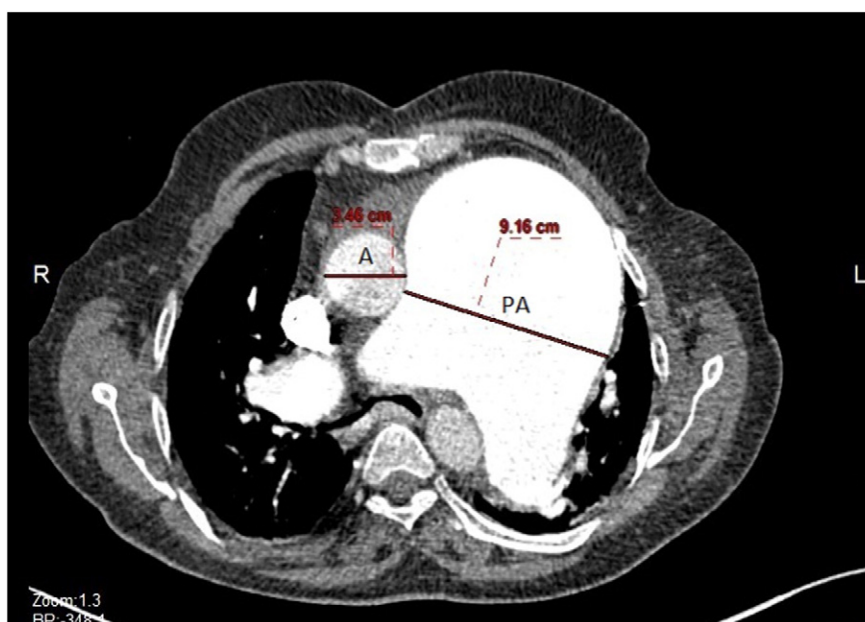


Fig. 1. Computed tomographic scan at the level of bifurcation of the main PA shows measurements of the diameter of the main PA and aorta (A), which were used to calculate the PA/A ratio. PA/A ratio of this patient is 2.6.

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