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# Pulmonary artery size as a predictor of pulmonary hypertension and outcomes in patients with chronic obstructive pulmonary disease

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**KEYWORDS**
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**Summary**
*Rationale:* The relationship between pulmonary artery size with underlying pulmonary hypertension and mortality remains to be determined in COPD. We sought to evaluate the relationships in a cohort of patients with advanced COPD.
*Methods:* A retrospective study of advanced COPD patients evaluated between 1998 and 2012 was conducted at a tertiary care center. Patients with chest computed tomography images and right heart catheterizations formed the study cohort. The diameters of the pulmonary artery and ascending aorta were measured by independent observers and compared to pulmonary artery pressures. Intermediate-term mortality was evaluated for the 24-month period subsequent to the respective studies. Cox proportional hazards model was used to determine independent effects of variables on survival.

*Abbreviations:* COPD, chronic obstructive pulmonary disease; PA:A, pulmonary to aortic artery diameter ratio; PH, pulmonary hypertension; $FEV_1$, forced expiratory volume in 1 second; DLco, diffusing capacity for carbon monoxide; CT, computed tomography; mPAP, mean pulmonary artery pressure; RHC, right heart catheterization; sPAP, systolic pulmonary artery pressure; dPAP, diastolic pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure; HR, hazard ratio; PAD, pulmonary artery diameter; AUC, area under the ROC curve.

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*Results:* There were 65 subjects identified, of whom 38 (58%) had pulmonary hypertension. Patients with and without pulmonary hypertension had mean pulmonary artery diameters of 34.4 mm and 29.1 mm, respectively ($p = 0.0003$). The mean PA:A ratio for those with and without pulmonary hypertension was 1.05 and 0.87, respectively ($p = 0.0003$). The PA:A ratio was an independent predictor of mortality with a reduced survival in those with a PA:A >1 ($p = 0.008$).
*Conclusions:* The PA:A ratio is associated with underlying pulmonary hypertension in patients with COPD and is an independent predictor of mortality. This readily available measurement may be a valuable non-invasive screening tool for underlying pulmonary hypertension in COPD patients and appears to impart important independent prognostic information.


## Introduction

Chronic obstructive pulmonary disease (COPD) is now the third leading cause of death in the United States [1]. Known risk factors for mortality include the forced expiratory volume in 1 second ($FEV_1$), arterial blood gas values and age [2]. Recent studies have also demonstrated that smoking status, anemia, and reductions in lean body mass may be associated with reduced survival in this population [2–4]. Despite the ready availability of these parameters, the outcomes of COPD patients are still notoriously difficult to predict.

Pulmonary hypertension (PH) frequently complicates the course of patients with advanced COPD [5]. The presence of PH may be important to identify, as these patients tend to have greater oxygen needs, reduced functional ability, an apparent increased risk of acute exacerbations and an increased risk of mortality [5–7]. Indeed, areas on the composite BODE index performs well as a prognostic indicator could be attributable to its latter two components which may be affected by the presence of underlying PH.

It is difficult to predict the presence of underlying PH based on lung function alone given the lack of a clear relationship between the severity of PH and spirometric indices. Screening tools that have been touted include serologic markers (brain natriuretic peptide/N-terminal pro b-type natriuretic peptide), the six-minute walk test and a reduced single-breath diffusing capacity for carbon monoxide (DLco) [8–11]. The most commonly used screening tool for PH is echocardiography. However, this is inherently inaccurate, especially in patients with COPD, where severe hyperinflation often hinders the attainment of an adequate window [12].

Prior studies suggest a relationship between the pulmonary arterial (PA) diameter and PH in patients with various underlying disorders [13,14]. There is data to suggest a relationship between PA size and acute exacerbations of COPD [13,15]. A recent smaller retrospective study presented data that suggests a correlation between pulmonary artery size on computed tomography (CT) images and pulmonary artery pressures on right heart catheterization (RHC) [16]. However, the prognostic value of PA size remains unclear and uninvestigated in patients with COPD. We therefore sought to validate the relationship between PA:A ratio and PA diameter size on CT imaging with the mean pulmonary artery pressure (mPAP) measured by RHC in a cohort of COPD patients. In addition, we also sought to evaluate the prognostic ability of these readily available CT measurements in comparison to other more commonly established COPD prognostic indicators, including the $FEV_1$ and mPAP.

## Methods

Patients with a primary diagnosis of COPD evaluated in an Advanced Lung Disease clinic for potential lung transplantation or volume reduction surgery between January 1998 and December 2012 were identified. Only those with available chest CT scans and contemporaneous RHC data were eligible to be included in this study. For those with PH, a comprehensive evaluation was undertaken to exclude other potential contributors to their PH.

The PA:A ratio was calculated from the diameters of the PA and ascending aorta measured by five of the authors who independently and in a blinded fashion read the CT scans of all the patients. The PA segment was measured at the bifurcation with the greatest diameter of the aorta measured at the same level [15]. These were compared to the mPAP, systolic pulmonary artery pressure (sPAP), and the diastolic pulmonary artery pressure (dPAP), as measured on RHC. A subgroup analysis, excluding those with ascending thoracic aorta dilation/aneurysm and pulmonary capillary wedge pressures (PCWP) > 15 mmHg on RHC [World Health Organization (WHO) Group II PH], was performed [17]. The definition of ascending thoracic aorta aneurysm/dilation accounted for the effects of age and gender [18].

Transplant-free survival based on the PA segment size, the PA:A ratio, the mPAP and the $FEV_1$ were evaluated over the 2-year period subsequent to the respective studies. Time zero for each patient from which survival was calculated was the date of the CT scan, the date of the RHC and date of the pulmonary function tests (PFTs), respectively. Patients were censored at the time of death or lung transplantation. The study was approved by the Inova institutional review board (IRB00002273).

## Statistics

All demographic and PFT data are presented as means if continuous, or as frequencies if categorical with standard

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