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Clinical relevance of pulmonary infarction in patients with pulmonary embolism

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ABSTRACT

Introduction: Data regarding the clinical relevance of pulmonary infarction (PI) in patients with pulmonary embolism (PE) are lacking. The aim of this study was to investigate the clinical features of PE patients with PI and the prognostic role of PI for PE patients.
Materials and Methods: Based on computed tomography scan, 509 patients with PE were divided into two groups, the infarction group (n = 45) and the non-infarction group (n = 464). A variety of clinical parameters were compared between the two groups.
Results: In the infarction group, the largest pulmonary arteries involved by emboli were central rather than peripheral and more proximal as compared to the non-infarction group (p = 0.01 and p < 0.03, respectively). Thrombolytic agents tended to be more frequently administered in the infarction group (13.3% [n = 6] versus 6.3% [n = 29], p = 0.07). In-hospital mortality, PE-related deaths, and the recurrence rate of PE did not differ between the two groups.
Conclusions: The present study did not demonstrate that PI is a prognostic indicator of recurrence and mortality in PE patients. We suggest the possibility that blood clot burden is greater in PE patients with PI, although PI by itself occurs in small pulmonary arteries.

Introduction

Pulmonary embolism (PE) has diverse clinical spectrum, ranging from an asymptomatic event in a previously healthy person to sudden death [1]. Pulmonary infarction (PI) may or may not occur in association with PE [2]. Pathologically, PE can lead to a pulmonary hemorrhage in an area distal to the embolic obstruction; pulmonary hemorrhages that are not resorbed will consequently progress to PI [2]. Multi-detector row computed tomography (MDCT) scan has recently been employed as an acceptable, although not accurate, diagnostic modality for PI [3–5].

The lung receives blood from two separate vascular systems: the pulmonary and bronchial arteries [6], and the pulmonary parenchyma receives oxygen from the airways [7]. Only approximately 10% of pulmonary emboli cause PI, due to multiple oxygen sources for the lung [8]. The size of an occluded pulmonary artery and underlying medical conditions are the two most important factors associated with development of PI. Occurrence of PI is more common in peripheral PE than in central PE [2]. Dalen et al. [2] suggested correlation between the size of the occluded pulmonary artery and development of an infarct; in addition, they reported that occurrence of PI was not common when central arteries were obstructed by emboli, but PI frequently occurred when distal arteries were involved. More specifically, PI was found to be more commonly associated with occlusion of pulmonary arteries of 3 mm or less in diameter, compared to larger ones [9]. Second, occurrence of PI is more common in patients with underlying conditions such as heart disease, particularly congestive heart failure, chronic lung disease, and malignancy, compared to patients without these comorbidities [1,2,9].

Data regarding the role of PI as a prognostic factor in patients with PE is limited. Some researchers have suggested that PE patients with the clinical syndrome of PI characterized by pleuritic chest pain or hemoptysis may be less severe and the mortality rate for those patients may be lower, compared to those without PI [10–12]. However, those studies were based on patients' symptoms rather than on detection of a "true" infarct. Thus, the prognostic implication of PI in patients with PE remains unclear. This study was conducted in order to investigate the prevalence, clinical features, and clinical course and outcome of PE patients with PI, thereby elucidating whether PI may have prognostic significance for patients with PE.

Methods

Study Population

For this retrospective study, we searched the computer-based database for patients ≥ 18 years of age who underwent CT pulmonary

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angiography with or without indirect CT venography and who were diagnosed with a PE between September 2003 and December 2010 at the Kyungpook National University Hospital (KNUH), a tertiary referral center in Daegu, South Korea. The study population included 509 patients with PE. This study was approved by the Institutional Review Board of the KNUH, and written informed consent was waived because this study was retrospective.

Clinical Data

The medical records of patients were reviewed for demographics, clinical characteristics, laboratory data, clinical course, and survival data. A subject who had smoked at least once a day for at least 1 year in his or her lifetime was regarded as an ever-smoker. Cumulative cigarette dose (pack-years) was calculated using the following formula: pack-years = (packs/day) x (years smoked). The clinical characteristics included body-mass index (BMI), presenting manifestations, the presence of pleuritic chest pain and hemoptysis, risk factors, comorbid conditions, and clinical prediction rules. Provoked PE was defined by the presence of reversible provoking risk factors, including surgery, trauma, active cancer, pregnancy, puerperium within three months of PE or immobilization (bed rest within the past month for most of the day for 3 or more consecutive days) [13].

The mortality rate, causes of death, and recurrence rate of PE were compared between the PE patients with and without PI. By modifying the method of Musset et al. [14], we categorized the deaths on the basis of available information as related to PE (certainly or possibly), not related to PE, or unknown.

Radiologic Data

CT scans were performed using a multidetector CT (MDCT) with 16 or 64 detector rows: Light Speed 16 (General Electric, Milwaukee, WI, USA) or Aquilion 64 scanner (Toshiba Medical Systems, Japan). The scan was obtained during a single inspiratory breath hold in the craniocaudal direction ranging from the apex to the diaphragm. The CT parameters used for 16-channel MDCT were 120 kVp and a 16×0.75 mm collimation with a pitch of <1.5. The parameters used for 64-channel MDCT were 120 kVp and 64×0.5 mm collimation with a pitch of <1.5. A standard dose (2 ml/kg; up to 150 ml) of low osmolar non-ionic contrast media (Optiray 350, Mallinckrodt Inc., Hazelwood, MO, USA) was injected through an arm vein at a rate of 2.5-3 ml/sec. Individual optimization of peak enhancement time was achieved by using bolus tracking within the main pulmonary artery. The threshold value for triggering data acquisition was set to 250 Hounsfield Unit. Indirect CT venography was utilized to image from the diaphragm inferiorly to the ankles to detect deep vein thrombosis (DVT) 140 seconds after a thoracic scan.

As described in an earlier study [15], PE was diagnosed on CT scan as a sharply delineated pulmonary arterial filling defect present in at least two consecutive image sections and located centrally within the vessel or with acute angles at its interface with the vessel wall (Fig. 1). The diagnosis of PI was based on the presence of a peripheral consolidation in the region of segmental or subsegmental PE, irrespective of pleuritic chest pain or hemoptysis, based on the modified criteria of a recent study (Fig. 1) [5]. To diagnose PE and to determine the presence of PI, and to determine the sites of the most proximal pulmonary arteries in which emboli were located, CT scans were reviewed separately by two experienced radiologists (K.M.S. and J.L.) who were blinded to the patients' clinical information. In case of discrepancies in the readings of the two radiologists, a final decision was reached by consensus. A proximal DVT was defined as a thrombosis at the level of the popliteal vein or above and a distal DVT was defined as a thrombosis affecting the axial calf veins [16]. The size of pleural effusion was assessed in a semiquantitative manner. Small, moderate, and large effusions were defined as <3 cm, 3–5 cm, and >5 cm, respectively, at maximal depth [17].

Statistical Analysis

Statistical analyses were performed using SPSS software, version 12.0 (SPSS Inc., Chicago, IL, USA). The data are expressed as the mean ± standard deviation (SD) or median with interquartile range (IQR), if the data were skewed for continuous variables, and percentages for categorical variables. Between the two groups, the continuous variables were compared by Student's *t*-test and Mann–Whitney *U* test if non-normally distributed, whereas the categorical variables were compared using a chi-squared test or Fisher's exact test. Kaplan-Meier estimates and Cox proportional hazard regression analyses were used to study the relationships between independent variables and survival parameters. The inter-observer agreement between the two radiologists was assessed using kappa statistics.

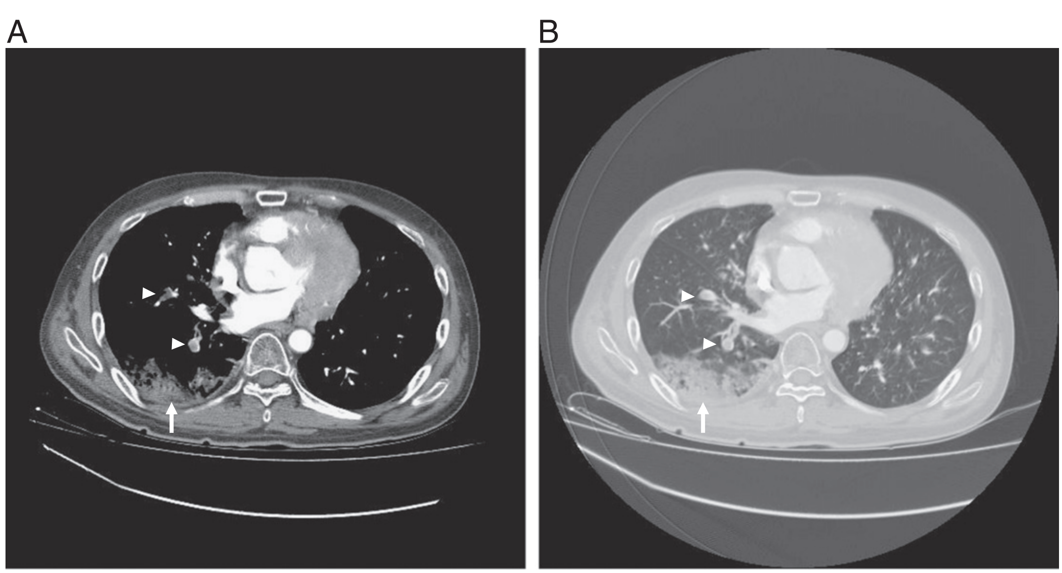

Fig. 1. Chest CT (1A, mediastinal window; and 1B, lung window) shows that pulmonary emboli (arrow heads) are located in the segmental and subsegmental pulmonary arteries as sharply delineated arterial filling defects in consecutive image sections. Pulmonary infarction (arrows) is identified as a wedge-shaped peripheral consolidation in the territory of a segmental embolus.