**Diffusion-weighted magnetic resonance imaging of thorax in diagnosis of pulmonary embolism**

Sevgi Yumrutepe¹, Muhammet Gokhan Turtay², Hakan Oguzturk², Zeynep Aytemur¹, Taner Guven¹, Kasim Turgut⁴, Ali Gur²

¹Malatya Education Research Hospital Emergency Medicine Malatya, Turkey  
²Inonu University, Faculty of Medicine Department, Emergency Medicine, Malatya, Turkey  
³Inonu University, Faculty of Medicine Department of Pulmonary Medicine, Malatya, Turkey  
⁴Adıyaman, Research and Training Hospital, Department of Emergency Medicine, Adıyaman, Turkey

Received 06 February 2018; Accepted 11 April 2018  
Copyright © 2018 by authors and Medicine Science Publishing Inc.

**Abstract**

Pulmonary embolism (PE) has a high mortality rate and a considerable incidence in emergency care. Thorax computed tomography (CT) angiography is the primary diagnosis method for PE, but has many contraindications. In the present study, we aimed to determine the usability of Diffusion-weighted magnetic resonance imaging (DWMRI) in diagnosis of pulmonary embolism. Patients, diagnosed as pulmonary embolism previously by thorax CT angiography, were taken DWMRI. Demographic parameters, complaints, laboratory values and imaging findings were recorded on standard forms. Twenty nine patients, who were diagnosed as pulmonary emboli, were evaluated. Many of them were female (69%) and the mean of age was 61 years. Dyspnea and chest pain were the main complaints. Atelectasis (69.1%) and pulmonary infarct (30.9%) were determined lesions on CT and DWMRI. Region of interest (ROI) were determined by using MRI (T2) images. Three different ROI values were placed on areas and apparent diffusion coefficient (ADC) values were calculated for peripheral lung lesions. Significant difference was determine between mean ADC values of atelectasis and pulmonary infarct lesions (p<0.05). DWMRI can differentiate peripheral lesions in PE patients, but it is not adequate for diagnosis of PE.

**Keywords:** Diffusion-weighted magnetic resonance imaging, dyspnea, lung disease, pulmonary embolism

**Introduction**

Pulmonary embolism (PE) diagnosis is rather difficult due to nonspecific signs and symptoms. The PE is the third most common cardiovascular disease that is seen in emergency services, following coronary artery disease and stroke [1]. Mortality rates are up to 10% [2]. When PE is accurately diagnosed and treated, this rate could be reduced to 3% [3].

Thorax computed tomography (CT) angiography, with a specificity rate of 96%, is the most frequently used technique to confirm the diagnosis of PE [1]. However, the exposure to radiation, contrast media and the long exposure period during CT are the disadvantages of this technique. Thus, thorax CT angiography cannot be used in patients; with renal failure, who have contrast media allergies, and unstable patients who require rapid imaging.

Magnetic resonance imaging (MRI) became an alternative to CT in lung imaging because of no radiation risk [4].

Diffusion weighted magnetic resonance imaging (DWMRI) is a technique that can be obtained during a single hold of breath and does not require the use of a contrast medium, and has been initially used in early diagnosis of strokes in neuroradiology [5,6]. The use of this technique was initially limited in brain examinations since it was very sensitive to cardiac, respiratory, and peristaltic movements, but with the development of rapid MRI sequences such as echo-planar imaging, its use expanded to other physical parts [7]. With DWMRI, the apparent diffusion coefficient (ADC) for tissues and lesions is calculated and obtained values can be used in differential diagnosis [8]. There are some studies where DWMRI was used to diagnose various neoplastic and non-neoplastic diseases in lungs [9,10].

The aim of the present study is to investigate the significance and usability of thorax DWMRI in PE by conducting thorax DWMRI on patients previously diagnosed with PE by thorax CT angiography.

**Materials and Methods**

This study was approved by the Inonu University Clinical Research ethics committee (approval no: 2010/124). Informed consent was obtained from all participants prior to inclusion in the study.

This study was conducted with 29 patients diagnosed with PE using thorax CT angiography between January 2011 and December 2011.
The following data was obtained from each subject: Age, gender, complaints during admission to the hospital, the laboratory results (hemoglobin, platelet, white blood cell, hematocrit, glucose, BUN, creatinine) and imaging (chest X-ray, thorax CT angiography) findings were recorded in the patient files. Then, thorax DWMRI was taken to all patients who were diagnosed as PE by using thorax CT angiography previously.

**MR imaging**
The study was conducted with a superconducting MRI device (Gyroscan Intera master, Philips, best Netherlands) with a main magnetic field of 1.5 Tesla and a gradient power of 32 mTesla / m, and a trigger was used to prevent artefacts caused by linear polarized body coil and respiratory movements. Initially, axial T2 weighted conventional echo planar pulse sequence (TR 3540 ms, TE 90 ms) was applied to the cases. Then, diffusion weighted imaging (DWI) [TR 5000 ms, TE 100 ms, FOV 350 mm², cross-sectional thickness 8 mm, interlice gap 1 mm] value was taken with a single-shot echo planar pulse sequence with two different b values (0 and 1000 s / mm²).

Two different b values (0 and 1000 s / mm²) were used in patients. Diffusion gradients were applied on 3 planes (x, y, z). ADC mapping was obtained automatically with software. The ADC value that determines the water diffusion coefficient was obtained by the signal regression analysis. Based on T2 images, the oval and round shaped region of interest (ROI) was determined, and the value measured at a certain pixel was automatically calculated by the computer. The mean ADC value was also automatically calculated with the corresponding pixel value in the ADC map. The mean ADC value was calculated by placing 3 different ROIs in the consolidation area. The ROI included 100-800 pixels and the average of the three obtained values was used in the statistical analysis.

**Statistical analysis**
Statistical analysis was performed with the Statistical Package for Social Sciences (SPSS) version 18.0 (Chicago, IL, USA). Measurable variables are presented in Mean ± Standard Deviation. The normal distribution of ADC values was determined by the Shapiro Wilks Normality test. The significance of the difference between atelectasis and infarct was determined by independent samples t test. P <0.05 values were considered statistically significant.

**Results**
Twenty-nine patients who admitted to the hospital and diagnosed with PE with thorax CT angiography between January 2011 and December 2011 were investigated prospectively. Nine of the 29 patients (31%) were male and 20 (69%) were female. The mean age was 61 (±16.7) years. We found that the most common complaints were dyspnea and chest pain (78.2% and 40.8%, respectively) among patients in the study. In 9 (31%) patients, infarct was detected in the lung parenchyma and in 20 (69%) patients lesions were consistent with atelectasis. No other lesions were detected in DWMRI, and findings were correlated with those of thorax CT angiography (Figures 1,2,3).

For all observed lesions, ADC measurements were conducted with DWMRI. The mean ADC value was 2.39x10⁻³ ± 4.6 mm² / sec for all lesions, and the mean ADC value was 1.98x10⁻³ ± 4.5 mm² / sec for lesions consistent with the infarct. The average ADC value for atelectasis sites was measured as 2.57 × 10⁻³ ± 3.3 mm² / sec (Table 1). The difference between atelectasis and infarct based on the ADC values was statistically significant (p = 0.0001).

**Discussion**
The most common symptoms of PE are dyspnea and chest pain [11,12]. In the present study, it was determined that dyspnea was the most common symptom in PE with 78.2% prevalence followed by the chest pain with 40.8% rate.

Previous studies reported that multisliced CT could replace conventional pulmonary arteriography in evaluation of PE [13]. Today, thorax CT angiography is the most common technique used in PE diagnosis [14]. In the present study, we used thorax CT angiography technique for the diagnosis of PE. Thorax CT angiography is used as the first diagnostic method in our emergency service, because it can give us accurate diagnosis in a short time.

PE risk increases five times during pregnancy and it is one of the important causes of maternal morbidity and mortality during and after pregnancy, however there is no adequate diagnostic approach for PE during pregnancy [15,16]. Thorax CT cannot be performed in pregnancy, in case of renal failure and contrast medium allergy [16]. In recent years, MRI has been increasingly
Ethical approval
The study was started after the approval of Inonu University Ethical Commission (No: 2010/124).

References