

ORIGINAL ARTICLE

Medicine Science 2018;7(4):759-61

Diffusion-weighted magnetic resonance imaging of thorax in diagnosis of pulmonary embolismSevgi Yumrutepe¹, Muhammet Gokhan Turtay², Hakan Oguzturk², Zeynep Aytemur³, Taner Guven¹, Kasim Turgut⁴, Ali Gur²¹Malatya Education Research Hospital Emergency Medicine Malatya, Turkey²Inonu University, Faculty of Medicine Department, Emergency Medicine, Malatya, Turkey³Inonu University, Faculty of Medicine Department of, Pulmonary Medicine, Malatya, Turkey⁴Adiyaman, Research and Training Hospital, Department of Emergency Medicine, Adiyaman, Turkey

Received 06 February 2018; Accepted 11 April 2018

Available online 09.07.2018.with doi: 10.5455/medscience.2018.07.8837

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 standart 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 peripheric lung lesions. Significant difference was determine between mean ADC values of atelectasis and pulmonary infarct lesions ($p<0.05$). DWMRI can differentiate peripheric lesions in PE patients, but it is not adequate for diagnosis of PE.

Keywords: Diffusion-weighted magnetic resonance imaging, dyspnea, lung disease, pulmoary 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.

*Corresponding Author: Kasim Turgut, Adiyaman, Research and Training Hospital Department of Emergency Medicine, Adiyaman, Turkey
E-mail: kasimturgut@yahoo.com

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 (Gyrosan 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 turbo spin echo 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 T2A 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 $2.39 \times 10^{-3} \pm 4.6 \text{ mm}^2 / \text{sec}$ for

all lesions, and the mean ADC value was $1.98 \times 10^{-3} \pm 4.5 \text{ mm}^2 / \text{sec}$ for lesions consistent with the infarct. The average ADC value for atelectasis sites was measured as $2.57 \times 10^{-3} \pm 3.3 \text{ mm}^2 / \text{sec}$ (Table 1). The difference between atelectasis and infarct based on the ADC values was statistically significant (p = 0.0001).

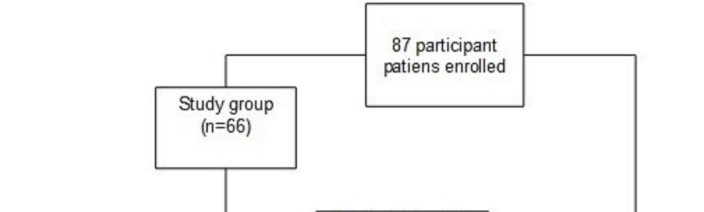


Figure 1. Infarct site of the same patient in thorax CT and diffusion-weighted MR imaging

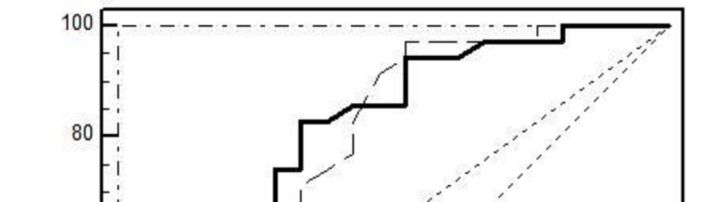


Figure 2. Atelectasis and pleural effusion site of the same patient in thorax CT and diffusion-weighted MR imaging

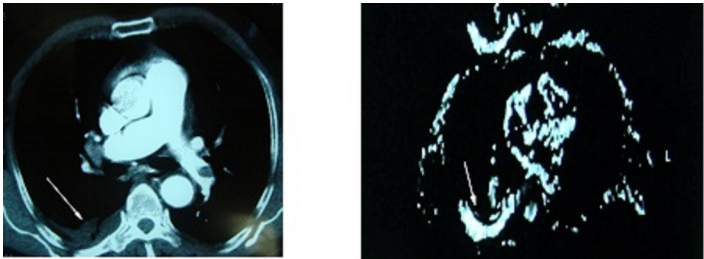


Figure 3. Infarct and pleural effusion site of the same patient in thorax CT and diffusion-weighted MR imaging

Table 1. Mean ADC values for infarct and atelectasis in DWMRI

Variable	Infarct (I)	A telectasis (A)	I+A	
ADC (mm²/sec	$19.98 \times 10^3 \pm 4.5$	$2.57 \times 10^3 \pm 3.3$	$2.39 \times 10^3 \pm 4.6$	0.0001

ADC: apparent diffusion coefficient, DWMRI: diffusion-weighted resonance imaging

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

used for the diagnosis of several diseases. Since it does not require iodized contrast media and radiation, MRI is superior to thorax CT angiography. MRI could be used in patients with renal failure, iodine contrast medium allergy, and during pregnancy [17].

The ADC values calculated with DWMRI depend on the specific diffusion capacities of biological tissues. The ADC value is highly dependent on the presence of diffusion barriers in cell membranes, fibers, macro-molecules, and cell organelles, called water microenvironment [18]. Different cellular building compartments can reveal dissimilar ADC values. Thus, ADC values could help determine different tissue types and tissue characteristics [19,20]. ADC values are at lower levels in various tumors with denser protons when compared to benign tissues and necrosis where the protons are less dense. Since tumors are more cellular than the tissue they originate from, they contain signaling features such as diffusion restriction in DWI [21]. In the present study, it was observed in thorax DWMRI that all patients diagnosed as PE, also had lesions in the lung periphery. We constituted the ADC maps from peripheral lesions and calculated mean ADC values. Based on these ADC values, the difference between atelectasis and infarct sites was determined as significant ($p < 0.05$). Thus, ADC values that would be detected with diffusion MRI in patients diagnosed with PE may help us to differentiate the atelectasis and infarct sites. However, it was determined that it is difficult to diagnose the PE by observing the thorax DWMRI. This was the first study that aimed to determine the ADC values in peripheric lesions seen in PE.

In the past, MRI was utilized for morphologic imaging of lungs. However, current MRI techniques enabled functional imaging of the lungs. Although DWMRI is a difficult technique, it is now possible to obtain DWMRI of the chest and mediastinum with MRI scanners. Despite the limited clinical experience, the use of DWMRI has shown promising results in the characterization and staging of the lung cancer, evaluation of mediastinal and pleural pathologies, determination of the characterization of pulmonary nodules, and characterization of lymph nodes and lung metastases, and ongoing research has enabled noninvasive evaluation of mediastinum by diffusion imaging technique [4,22].

In the present study, it was not possible to standardize the time of onset of patient complaints and the time of diagnosis of pulmonary embolism for all patients. Thus, to obtain clearer findings about the significance and availability of thorax DWMRI in the diagnosis of pulmonary embolism, it was concluded that the time of onset of patient complaints and the time it took to diagnose the PE should be standardized, and further studies that would be conducted with higher number of patients were required.

Conclusion

DWMRI can not be used for diagnosis of PE. It can only help us to differentiate peripheral lung lesions in PE by the ADC values. Thorax CT angiography is still the first diagnostic method for PE.

Competing interests

The authors declare that they have no competing interest.

Financial Disclosure

There are no financial supports

Ethical approval

The study was started after the approval of Inonu University Ethical Commision(Nu: 2010/124).

References

1. Burns SK, Haramati LB. Diagnostic imaging and risk stratification of patients with acute pulmonary embolism. *Cardiol Rev*. 2012;20:15-24.
2. Ballantine M, Bhimani M, Milne WK. Diagnostic approach to pulmonary embolism in a rural emergency department. *Can J Rural Med*. 2012;17:17-20.
3. Arseven O. Venous thromboembolism. In: Ozlu T, Metintas M, Ardic S, edition. *Basic Data about Lung Diseases*. Ankara, 2008;341-56.
4. Henzler T, Schmid-Bindert G, Schoenberg SO, et al. Diffusion and perfusion MRI of the lung and mediastinum. *Eur J Radiol*. 2010;76:329-36.
5. Warach S, Chien D, Li W, et al. Fast magnetic resonance diffusion-weighted imaging of acute human stroke. *Neurology* 1992;42:1717-23.
6. Lutsep HL, Albers GW, DeCrespigny A, et al. Clinical utility of diffusion-weighted magnetic resonance imaging in the assessment of ischemic stroke. *Ann Neurol*. 1997;41:574-80.
7. Muller MF, Prasad P, Siewert B, et al. Abdominal diffusion mapping with use of a whole-body echo-planar system. *Radiology* 1994;190:475-8.
8. Sinha S, Lucas-Quesada FA, Sinha U, et al. In Vivo Diffusion-Weighted MRI of the Breast: Potential for Lesion Characterization. *J Magn Reson Imaging*. 2002;15:693-704.
9. Baysal T, Bulut T, Gokirmak M, et al. Diffusion weighted MR imaging of pleural fluid differentiation of transudative vs exudative pleural effusions. *Eur Radiol* 2004;14:890-6.
10. Baysal T, Mutlu DY, Yoloğlu S. Diffusion-weighted magnetic resonance imaging in differentiation of postobstructive consolidation from central lung carcinoma. *Magn Reson Imaging*. 2009;27:1447-54.
11. Miniati M, Prediletto R, Formichi B, et al. Accuracy of clinical assessment in the diagnosis of pulmonary embolism. *Am J Respir Crit Care Med* 1999;159:864-71.
12. Duru S, Ergün R, Dilli A, et al. Clinical, laboratory and computed tomography results in pulmonary embolism: Retrospective evaluation of 205 patients. *Anatol J Cardiol*. 2012;12:142-9.
13. Patel S, Kazerooni EA. Helical CT for the evaluation of acute pulmonary embolism. *AJR Am J Roentgenol*. 2005;185:135-49.
14. Hunt JM, Bull TM. Clinical review of pulmonary embolism: diagnosis, prognosis, and treatment. *Med Clin North Am*. 2011;95:1203-22.
15. McLintock C, Brighton T, Chunilal S, et al. Recommendations for the prevention of pregnancy associated venous thromboembolism. Councils of the Society of Obstetric Medicine of Australia and New Zealand; Australasian Society of Thrombosis and Haemostasis. *Aust N Z J Obstet Gynaecol*. 2012;52:3-13.
16. Arseven O, Sevinc C, Alatas F, et al. Actual diagnostic and treatment modalities for pulmonary embolism. *Turkish Thoracic J*. 2009;10:7-47.
17. Savas I. Pulmonary thromboembolism. In: Savas I, Acican T, Atasoy C. et al. Eds. 2009. *Chest Diseases*. Poyraz. Ankara:369-76
18. Benveniste H, Hedlund LW, Johnson GA. Mechanism of detection of acute cerebral ischemia in rats by diffusion-weighted magnetic resonance microscopy. *Stroke*. 1992;23:746-54.
19. Herneth AM, Naude J, Philipp M, et al. The value of diffusion weighted MRI in assessing the bone marrow changes in vertebral metastases. *Radiologe*. 2000;40:731-6.
20. Finelli DA. Diffusion-weighted imaging of acute vertebral compressions: specific diagnosis of benign versus malignant pathologic fractures. *AJNR Am J Neuroradiol*. 2001;22:241-2.
21. Provenzale JM, Mukundan S, Barboriak DP. Diffusion-weighted and perfusion MR imaging for brain tumor characterization and assessment of treatment response. *Radiology*. 2006;239:632-49.
22. Luna A, Sánchez-González J, Caro P. Diffusion-weighted imaging of the chest. *Magn Reson Imaging Clin N Am*. 2011;19:69-94.