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Original Article

화재사고시 흡입에 의한 기도손상의 핵의학적 평가

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Scintigraphic Evaluation of Inhalation Injury in Fire Victims

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Purpose: Conventional chest X-ray and pulmonary function test cannot sensitively detect inhalation injury. Bronchoscopy is known to be the gold standard but it is invasive method. We evaluated whether lung inhalation/perfusion scans can sensitively detect inhalation injury of fire victims. **Materials and Methods:** Nineteen patients (male 9, female 10, mean age 31.6 yr) of fire victims were enrolled in this study. Inhalation lung scan was performed 2 days later after inhalation injury with ^{99m}Tc-technegas. Perfusion lung scan was performed 4 days later with ^{99m}Tc- MAA (macroaggregated albumin). Follow up lung scans were performed 16 and 18 days later for each. Chest X-ray was performed in all patients and bronchoscopy was performed in 17 of 19 patients at the same period. Pulmonary function test was performed in 9 patients. **Results:** Four of 19 patients showed inhalation and perfusion defects and one showed inhalation defect but, normal perfusion scan findings. These five patients with abnormal scan findings showed abnormal bronchoscopic findings and severe respiratory symptoms. On chest X-ray, 2 of them had pulmonary tuberculosis and one of them showed pulmonary congestion. FEV1/FVC was abnormal in 3 patients. On the follow up scan, all patients with abnormal initial scan findings showed improved findings and they had improved clinical state. **Conclusion:** Inhalation/perfusion lung scans can detect inhalation burn injury noninvasively in early stage and may be useful in therapeutic decision making and follow up of patients. (Nucl Med Mol Imaging 2006;40(1):28-32)

Key Words: Inhalation injury, Inhalation scan, Bronchoscopy, ^{99m}Tc-technegas

Introduction

Inhalation injury is the major cause of fatality in burn patients. Early detection is important for inhalation injury victims, since they can receive intensive therapy before pulmonary edema develops.

Inflammatory occlusion of terminal bronchioles and necrosis of the endobronchial mucosa render the airway and pulmonary parenchyma susceptible to infection and the resulting pneumonitis further increases mortality.[1] Clark et al. reported that smoke inhalation has a major influence on the pulmonary complication that may occur after fires,[2] but there is still a lack of a simple, sensitive and effective diagnostic modality for evaluating the lung condition in patients with inhalation injury. Bronchoscopy is accurate to evaluate the inhalation injury, but in some cases it is difficult to do immediately after injury. Lung scans are more easier and safer than bronchoscopy and good modality as bronchoscopy. Lin et al.[3] reported that conventional chest X-ray and pulmonary function test are not good modalities for evaluating inhalation injury in fire victims because of their low sensitivity. They also reported that ^{99m}Tc-DTPA aerosol inhalation scintigraphy can provide an objective evaluation and may be useful in therapeutic decision-making and disease monitoring. Recently ^{99m}Tc-technegas was used as inhalation lung scan agent, due to its good resolution, safety and

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Table 1. Detailed Data of 5 Patients with Abnormal Scan Findings

No.	Sex	Age	FEV1	FVC	FEV_1/FVC	CxR	Bronchoscopy	Inhalation scan	Perfusion scan
1	M	44	2.65	4.13	64%	Inflammatory change in right lung	Bronchial obstruction at superior segment of both lower lobes and left upper lobe	Defect in superior segment of both lower lobes and left upper lobe	normal
2	M	33				Pulmonary edema	Ulcerative lesion in right lower bronchus	Multiple ventilation defects in both lung fields	Decreased uptake in both upper lobes
3	F	53	1.97	1.35	64%	Normal	Bronchial obstruction at anterior segment of right upper lobe and lingular segment of left upper lobe	Decreased uptake in anterior segment of right upper lobe, right lower lobe and lingular segment of left upper lobe	Decreased uptake in anterior segment of right upper lobe
4	F	49				Tuberculosis in right upper lobe	Stenosis at posterior segment of right upper lobe	Defect in right upper lobe	Defect in right upper lobe
5	M	22	1.89	0.99	52%	Normal	Bronchial obstruction at anterior segment of right upper lobe and lingular segment of left upper lobe	Defect in lingular segment of left upper lobe	Decreased uptake in both lower lobes

comfortability compared with the ^{99m}Tc-DTPA aerosol. There has been few data that compare inhalation (especially using ^{99m}Tc-technegas) and perfusion scans with bronchoscopy. We have studied inhalation lung scans using ^{99m}Tc-technegas and perfusion lung scans in the same patients with inhalation injury and compared the scan findings with the bronchoscopic results.

Materials and Methods

Nineteen patients (male 9, female 10, mean age 31.6 yr) in fire victims were enrolled in this study. Most of the patients complained dyspnea and chest discomfort. Inhalation lung scan was performed 2 days later after inhalation injury with ^{99m}Tc-technegas and perfusion lung scan was performed 4 days later with ^{99m}Tc-MAA. ^{99m}Tc-technegas inhalation lung scan was performed using a commercial delivery unit (Technegas Generator, Tetley Manufacturing Ltd, Sydney, Australia). By the resistive heating of a graphite crucible to 2500℃ in which a saline solution of 505 MBq of ^{99m}Tc-pertechnetate had been placed and dried. After generation of the aerosol, it was dispersed in a lead lined chamber in an atmosphere of 100% argon. Following inhalation of 100% oxygen for 3 min, all patients were given ^{99m}Tc-technegas by inhalation in several tidal volume breaths through a mouthpiece while wearing a nose clip in the sitting position without breath holding.

^{99m}Tc-MAA (185 MBq) was injected in the same patients in supine position. Images of the same projections as the ventilation imaging were acquired with dual head camera (Picker Prism 2000) for 150 sec (both inhalation and perfusion scan). Follow up inhalation/perfusion lung scans were performed 16 and 18 days later for each. Chest X-ray was performed in all patients and bronchoscopy was performed in 17 of 19 patients at the same period. Pulmonary function test was performed in 9 patients.

Results

Five of 19 patients showed abnormal scan findings. Four patients showed multiple inhalation defects in inhalation scans, but less perfusion defects in perfusion scans. One patient showed inhalation defect but normal perfusion scan finding. Bronchoscopy was done in 17 patients. Table 1 shows detailed data of 5 patients with abnormal scan findings. These patients with abnormal

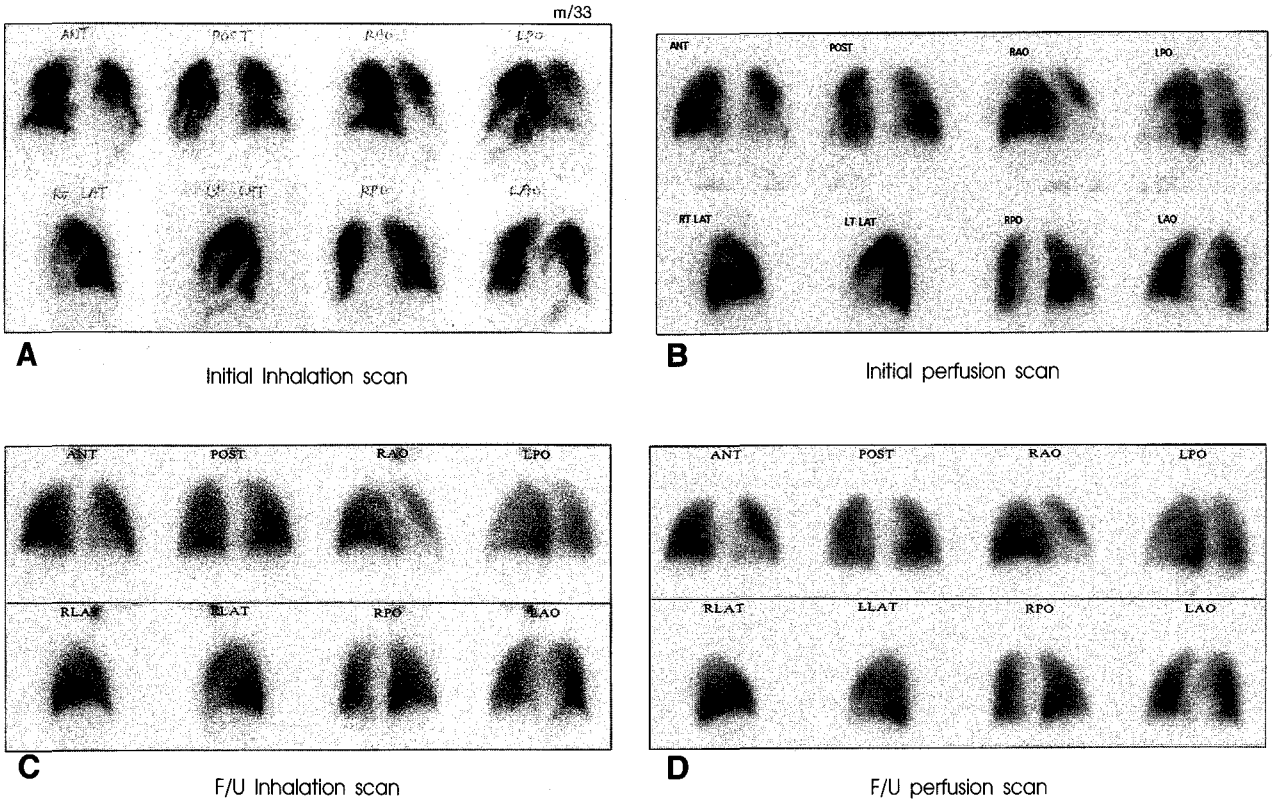

Fig. 1. Initial and follow-up inhalation/perfusion lung scans in patients No. 2. The patient showed multiple ventilation defects in both lung fields at inhalation scan and decreased uptake in both upper lobes at perfusion scan (A and B), but follow-up scans showed almostly normalized scan findings (C and D).

scan findings showed abnormal bronchoscopic findings which were consistent with the inhalation lung scan findings and severe respiratory symptoms, except patient No. 2. Patient No. 2 showed different findings between bronchoscopy and inhalation lung scan, probably due to bronchoscopy was done more delayed time interval (10 days later after injury) than other patients. Patient No.5 showed mismatched perfusion/inhalation lung scan, probably due to pulmonary embolism and follow up perfusion scan showed improved scan findings. On chest X-ray, 2 of them had pulmonary tuberculosis and one of them showed pulmonary congestion. FEV_1/FVC was abnormal in 3 patients who performed pulmonary function test. On the follow up scan, all patients with abnormal initial scan findings showed improved findings (Fig 1.) and they also had improved clinical state and improved bronchoscopic findings.

Among the 14 patients with normal scan findings, 12 patients who performed bronchoscopy showed normal bronchoscopic findings, except black pigmentation in some patients. Chest X-ray showed normal findings in 12 patients and mild pulmonary edema in 2 patients. FEV_1/FVC was normal in all 6 patients who performed pulmonary function test.

Discussion

Inhalation injury, present in approximately one third of burned patients treated at burn centers, increases mortality by a maximum of 20% in relation to age and extent of burn.[1] Inhalation injuries resulting from fires are uncommon in the lower airways and lung parenchyma, unless there is steam exposure.[4] When smoke is inhaled, the lungs are injured directly by the heat from the flames and , more importantly, by the products of incomplete combustion.[5,6] In the upper and major airways, heat injury and acute smoke inhalation cause edema, necrosis and sloughing of the mucosa,

bronchospasm, and cessation of ciliary movement of the bronchial epithelium. These conditions often lead to airway obstruction and atelectasis.[7,8] There are also occasional reports concerning the pulmonary embolism in the postburn population.[9] Shirani et al.[6] assessed the effects of inhalation injury and pneumonia on mortality in burn patients and they reported that pneumonia developed more frequently in patients with inhalation injury than the patients without inhalation injury.

Bronchoscopy should be performed in patients with clear evidence of smoke inhalation injury and in particular with facial burns in order to visualize the extent of airway injury, remove debris and give some indication of the likelihood of subsequent complications such as acute upper airways obstruction[7]. Bronchoscopy is accurate to evaluate the inhalation injury, but in some cases it is difficult to do immediately after injury. Lung scans are easier and safer than bronchoscopy and good modality as bronchoscopy. Lin et al.[3] reported that conventional chest radiograph and pulmonary function test are not good modalities for evaluating inhalation injury in fire victims and ^{99m}Tc-DTPA radioaerosol inhalation scintigraphy can provide an objective evaluation of inhalation injury during a fire accident and may be useful in therapeutic decision-making and disease monitoring. Previous reports evaluated the clearance rate with ^{99m}Tc-DTPA aerosol. Sundram et al.[4] studied alveolar-capillary permeability using ^{99m}Tc-DTPA aerosol in patients with inhalation burns and they showed increased rate of clearance (short half life). But in cases with inhomogeneous distribution of radioactivity, the clearance rate is not a reliable criterion for the detection of pulmonary injury in fire victims.[3] Recently ^{99m}Tc-technegas was used as inhalation lung scan agent, due to its good resolution, safety and comfortability compared with the ^{99m}Tc-DTPA aerosol. There were few data which compare directly inhalation/perfusion lung scans with bronchoscopic findings.

In this study, we used ^{99m}Tc-technegas and obtained more accurate visual data than previous DTPA aerosol scan and studied perfusion scan simultaneously, which can detect the complicating pulmonary embolism. The anatomic sites of defects in inhalation lung scan were concordant with the obstruction sites of bronchoscopic findings, except one patient who showed different findings between bronchoscopy and inhalation lung scan, probably due to bronchoscopy was done more delayed time interval than other patients because patient's condition. The perfusion scan was normal or less severe but, in cases with pulmonary embolism as a result of burn injury, perfusion scan was more severe than inhalation scan. On the follow up scan, all patients with abnormal initial scan findings showed improved findings and they had improved clinical state. Our study showed that inhalation lung scan directly reflect the inhalation injury (airway obstruction), which were concordant with bronchoscopic data and good modality for the early detection and monitoring of inhalation injury.

Inhalation lung scan, especially using ^{99m}Tc-technegas, is a safe, simple and accurate method for the early diagnosis of inhalation injury and good modality to evaluate the disease severity, therapeutic decision making and follow up after treatment.

요 약

목적: 현재로는 각종 유독가스 흡입으로 인한 기도 손상시 기관지 내시경 검사가 가장 정확하나, 시행이 어렵고 환자에게 불편감을 주는 검사법이다. 반면, 폐환기/관류스캔은 비침습적이며 유용한 검사법으로서, 연구자들은 흡입에 의한 기도손상환자에서 조기 검사 및 추적검사를 실시하여 이들 스캔의 유용성을 평가하고자 하였다. **방법**: 지하철 화재사고로 인한 기도손상이 의심되는 19명의 환자(남자: 9, 여자: 10, 평균연령: 31.6세)를 대상으로 하였다. 사고 2일 후 ^{99m}Tc-technegas 를 이용한 환기스캔을 실시하고, 4일 후 ^{99m}Tc-MAA 를 이용한 폐관류스캔을 실시하였다. 비슷한 시기에 실시한 기관지 내시경 검사 소견과 스캔소견을 비교하고 환자의 증상이 호전된 후 추적검사(환기스캔은 16일 후, 관류스캔은 18일 후)를 실시하였다. **결과**: 19명의 환자 중 14명은 정상스캔 소견을 보였고, 4명은 환기와 관류스캔 모두에서 결손의 소견을 보였으며, 나머지 1명은 환기스캔에서만 결손의 소견을 보였다. 비정상 소견을 보인 5명의 환자들은 스캔소견의 비정상부위와 기관지 내시경 검사에서 이상소견을 보인 부위가 유사하였고, 심한 호흡기 증상이 있었다. 흉부 X선 검사에서 이들 중 2명은 결핵을 앓은 흔적이 관찰되었다. 추적검사에서는

이상소견을 보인 모든 환자에서 스캔소견의 호전과 함께 임상소견도 호전되었다. **결론**: 환기/관류 스캔은 화재에 의한 기도손상시 조기에 이를 진단할 수 있을 뿐만 아니라 추적관찰에도 유용할 것으로 생각된다.

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