Abstract

**Purpose.** Previous pathological investigations have reported bronchiolitis obliterans (BO) as the major long-term sequela of exposure to sulfur mustard. In this study, we investigated whether high-resolution computed tomography (HRCT) could be used as a noninvasive imaging modality to differentiate between mustard lung (as a subtype of BO) and other respiratory disorders.

**Materials and methods.** Three groups of patients with sulfur-mustard-induced lung injury (BO), severe chronic asthma (resistant asthma) and smoking habit, respectively, were recruited. Also 30 nonsmoking participants were recruited randomly as the control group. Pulmonary function tests (PFT) and HRCT were performed. Images were viewed with a window level of –450 and window width of 1,400 HU. All images were evaluated by an expert radiologist who was blinded regarding the patients’ diagnoses and clinical situations.

**Results.** Airway involvement was higher and more frequent than parenchymal involvement in the groups with chemical-induced injury and asthma in comparison with smokers. On the other hand, parenchymal involvement was more frequent than airway involvement in the smokers’ group in comparison with the other groups.

**Conclusions.** HRCT can be a very useful method for differentiating between mustard lung, resistant asthma and lung injuries due to cigarette smoking.

**Keywords** HRCT · Resistant asthma · Bronchiolitis obliterans · Sulfur mustard · Smoking

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**Abstract**

**Obiettivo.** Numerosi precedenti studi di anatomia patologica hanno dimostrato come la bronchiolite obliterante (BO) sia la conseguenza a lungo termine più frequente all’esposizione alle mostarde azotate (iprite). In questo studio abbiamo valutato se la tomografia computerizzata ad alta risoluzione (HRCT) possa essere impiegata come modalità di imaging non invasivo per la diagnosi differenziale tra il danno polmonare indotto da mostarde azotate (sottotipo di BO) ed altre patologie respiratorie.

**Materiali e metodi.** Sono stati reclutati tre gruppi di pazienti, rispettivamente affetti da bronchiolite obliterante indotta da mostarde azotate (BO), affetti da asma cronica (asma refrattaria) e fumatori. Sono stati scelti casualmente 30 soggetti non fumatori come gruppo di controllo. Tutti i pazienti sono stati sottoposti a test di funzionalità respiratoria (PFT) e HRCT. Le immagini sono state visualizzate con un livello di finestra di –450 UH ed un’ampiezza di finestra di 1,400 UH. Tutte le immagini sono state visionate da un radiologo esperto all’insaputa della diagnosi e della situazione clinica dei pazienti.

**Risultati.** Il coinvolgimento delle vie aeree è risultato maggiore e più frequente del coinvolgimento parenchimale nei gruppi di pazienti con danno polmonare chimicamente indotto e asmatici rispetto ai fumatori. D’altra parte il coinvolgimento parenchimale è risultato più frequente del coinvolgimento delle vie aeree nel gruppo di fumatori rispetto agli altri gruppi.

**Conclusioni.** L’HRCT risulta essere un metodo utile per la diagnosi differenziale tra il danno polmonare da mostarde azotate e bronchioliti obliteranti (BO) indotte da mostarde azotate.
Introduction

Mustard gas was extensively used against Iranian civilians and military forces during the Iran-Iraq war of the 1980s. It is well-documented that inhalation of sulfur mustard causes respiratory system injury. There is no common consensus about the pathophysiological basis of chronic pulmonary disease caused by mustard gas, but bronchiolitis obliterans (BO) has been proposed as the underlying cause [1].

Airway remodelling is often considered to contribute to the element of irreversible airflow obstruction, which is a feature of some patients with asthma, BO and chronic obstructive pulmonary disease [2]. Lung diseases such as resistant asthma and cigarette smoking can change the structure of the small airways and cause irreversible airflow obstruction and thus interfere with proper diagnosis of mustard lung by causing similar clinical features. High-resolution computed tomography (HRCT) may reveal these abnormalities in symptom-free patients as well [3]. Different studies have reported HRCT findings, but these studies were limited to a single disease or compared the diseases with healthy individuals [4–6]. On the other hand, histopathological studies are invasive and may not be suitable for some patients.

In this study, we attempted to identify HRCT features that may help in differentiating between mustard lung (as a subtype of BO syndrome), resistant asthma and lung injuries due to cigarette smoking.

Materials and methods

In an analytical cross-sectional study, we compared 90 cases (30 in each group) and 30 controls. The study was approved by the ethics committee of the university medical centre, and informed consent was obtained from all participants.

Patients

Three groups of patients, each consisting of 30 individuals, were selected.

Group 1: Sulfur-mustard-induced lung injury (bronchiolitis obliterans)

Participants were patients suffering from pulmonary disorders due to previous exposure to a single high dose of sulfur mustard gas during the Iran-Iraq conflict in 1988. They were all from Sardasht, a city in western Iran, and were randomly selected from the medical records available at our university hospital that provides tertiary medical care and maintains a large database of patients exposed to chemical warfare agents during the war. Inclusion criteria were documented exposure to sulfur mustard and a diagnosis of chronic pulmonary disease due to mustard gas (histological evidence from previous biopsies). Exclusion criteria were pneumonia and/or acute bronchitis, cigarette smoking or substance abuse and a history of tuberculosis or resection of one or more lobes of lung.

Group 2: Patients with severe chronic asthma (resistant asthma)

Thirty consecutive patients with documented resistant asthma according to the American Thoracic Society definition [7] were chosen from our pulmonary clinic. Inclusion criterion was a need for permanent treatment (>50% in year) with high-dose orally administered or inhalant steroids to remain in a mild or moderate phase. Exclusion criteria were gastroesophageal reflux disease and sinusitis.

Group 3: Smokers

This group consisted of patients referred to the pulmonary clinic with various respiratory problems, especially dyspnoea and cough, and a history of smoking. Exclusion criteria were exposure to sulfur mustard gas, receiving any medication for respiratory symptoms or corticosteroids, and substance abuse.

Control group

Thirty nonsmoking participants were recruited randomly as the control group. Exclusion criteria were a history of smoking or substance abuse, a history of any respiratory signs and symptoms and a history of allergy or pulmonary diseases.

Study design and procedure

For the 90 patients in the three groups (BO, resistant asthma and smokers), a patient history, complete physical examination and pulmonary function tests (PFT) were performed on