ORIGINAL ARTICLE

Mustard Gas Effects on Iranian Veterans After 20 Years as Shown on Chest High-resolution Computed Tomography: A Follow-up Study

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INTRODUCTION

Some chemicals, which can have significant health and environmental effects, are used as warfare agents. One of the chemicals frequently used as a chemical weapon is mustard gas. Mustard gas was first used in World War I (1). In this war, mortality due to mustard gas was 2.5% (2). The most recent use of this chemical weapon was in the 1980-1988 Iran-Iraq War (3). Approximately 10 years later, Khateri et al. evaluated survivors and found that they were suffering from respiratory (42.5%), ophthalmic (39.3%), and cutaneous (24.5%) complications (4). Mustard gas, or bis (2-chloroethyl) sulfide, is an alkylating agent with low solubility in water and high solubility in fat (5, 6). In its pure form, it is a colorless and odorless liquid, but it may have a garlicky odor due to impurities (7). This substance can readily penetrate clothing and skin and can be absorbed through the skin or respiratory tract. In its penetration pathway, it damages tissues and is then absorbed into the bloodstream. In the lungs, mustard gas can cause early and late complications (5). Early and acute effects include epithelial necrosis, accumulation of secretions and atelectasis, bronchial obstruction, hypoventilation, and hemorrhage (8). Chronic effects include chronic bronchitis, fibrosis, asthma, and bronchiectasis. Fibrosis may appear several years after exposure and can be evaluated by spirometry, diffusion capacity, and high-resolution computed tomography (HRCT) (9). It has also been shown that the incidence of lung cancer is higher in people exposed to mustard gas than the general population (10). HRCT is a powerful tool for the diagnosis of parenchymal and airway abnormalities (11).

Studies have reported varying results regarding the pulmonary complications of exposure to mustard gas. Ghanei et al. used HRCT to evaluate people with a history of exposure to various gases, and the most frequent abnormality was air trapping (38%) (12). Bagheri et al. examined 50 people with a history of exposure to mustard gas. HRCT was abnormal in all patients, and the most frequent finding was bronchial wall thickening, which was observed in all patients (13). Ghanei et al. also reported that bronchial

ABSTRACT

Introduction: Mustard gas is a known chemical weapon that was used in the 1980-1988 Iran-Iraq War. It causes many health problems, including serious respiratory damage. In this study, we used high-resolution computed tomography to assess the pulmonary complications after 20 years of veterans of the Iran-Iraq War who were exposed to mustard gas. Materials and Methods: This was a follow-up study conducted on 200 Iranian veterans with a history of exposure to mustard gas at least 20 years previously. High-resolution computed tomography was performed on all veterans and was interpreted by two independent expert radiologists who were blinded to the study. The frequency of high-resolution computed tomography findings was reported. Data were analyzed with statistical package for the social sciences version 20 software. Results: One hundred twenty veterans (60%) showed HRCT abnormalities. The most frequent high-resolution computed tomography findings were diffuse hyper-aeration, 63 (52.5%); interstitial opacity, 50 (41.7%); parenchymal opacity, 26 (21.7%); bronchiectasis, 15 (12.5%); sub-pleural air trapping, 13 (10.8%); and local fibrosis, 10 (8.3%). Generally, lower lobes were more frequently affected. Conclusion: This study showed a high frequency of abnormal high-resolution computed tomography findings in veterans who were exposed to mustard gas, and most abnormalities were irreversible. These findings included diffuse hyper-aeration, interstitial opacity, parenchymal opacity, bronchiectasis, sub-pleural air trapping, and local fibrosis.
wall thickening was the most frequent finding, which was observed in 90% of mustard gas-exposed veterans. They found that air trapping (76%) and bronchiectasis (74%) were the next most frequent findings (14). However, Emad et al. reported that chronic bronchitis (58.8%) was the most common finding in mustard-exposed people and that bronchiectasis was not so common (15).

In our study, we used high-resolution computed tomography (HRCT) to assess the pulmonary complications after 20 years of veterans of the Iran-Iraq War who were exposed to mustard gas.

MATERIALS AND METHODS

Patients

In this follow-up study, 200 Iranian veterans with a documented history of exposure to mustard gas in the Iran-Iraq War and who showed acute or chronic respiratory symptoms were selected as study patients. The patients were consecutively selected from 500 veterans with the abovementioned conditions who were registered in a mustard gas exposure data bank.

The following data were collected: age, history of pre-exposure respiratory illnesses, smoking history, current respiratory status, and symptoms at the time of exposure. Required data were obtained from the medical files available at the main university hospital in Yazd, Iran. All patients who were smokers, who had a history of respiratory disease before exposure to mustard gas, and who had a history of occupational exposure to respiratory contaminants were excluded from the study. All selected patients did not report any pulmonary problems prior to exposure to mustard gas. Most (76%) were between 15 and 20 years of age at the time of exposure.

HRCT

Patients completed a checklist of demographic data and respiratory symptoms, after which HRCT was performed using one scanner for all selected patients (device: Shimadzu spiral CT scanner, model SCT-7800TX, Japan). HRCT images of 1-mm slice thickness were obtained at 20-mm intervals. The images were taken in both deep inspiration and deep expiration in the supine position. The non-contrast images were obtained with a window special for lung parenchyma (-100 to -200), with a width of 1600-1800.

Images were interpreted by two independent expert radiologists who were blinded to the study. Agreement was calculated by the kappa statistic. In cases of disagreement, a third radiologist interpreted the findings. A form containing demographic and radiologic information was designed for data collection. The first part included demographic data; the second part included data about HRCT. The lungs were divided into five segments: left upper, left lower, right upper, right middle, and right lower. Six findings were considered most important: diffuse hyper-aeration, interstitial opacity, lung parenchymal opacity, bronchiectasis, local fibrosis, and sub-pleural air trapping.

Data were analyzed with statistical package for the social sciences (SPSS) version 20 software. The sample size was calculated by estimating prevalence in a population considering a type 1 error of 0.05, prevalence of 0.5, and 0.06 accepted absolute differences. The findings were reported as mean ± standard deviation. The range was reported. Also, the chi square test was used. P values less than 0.05 were considered statistically significant.

RESULTS

All patients were men, with a mean (± standard deviation) age of 38 (± 6.2) years (range: 32-78 years). They were exposed to mustard gas about 20 years before (18.9 ± 1.3) during the Iran-Iraq War (1980-1988). HRCT examinations were obtained between January 2006 and February 2007 for each patient. All had respiratory complaints of varying intensity, including chronic cough, dyspnea, suffocation, and hemoptysis. In 80 patients (40%), HRCT was normal. The other 120 patients (60%) had various HRCT findings. Table 1 shows the frequency of HRCT findings in the patients. Diffuse hyper-aeration was the most frequent finding, in 63 (52.5%) patients, followed by interstitial opacity (41.7%), parenchymal opacity (21.7%), bronchiectasis (12.5%), sub-pleural air trapping (10.8%), and local fibrosis (8.3%).

Regardless of the type of lesion, the lower lobes in both lungs were more frequently affected than the upper lobes: on HRCT, 17 (14.2%) patients had abnormalities in the left lower lobe, 17 (14.2%) patients had abnormalities in the right lower lobe, 3 (2.5%) patients had abnormalities in the left upper lobe, and 4 (3.3%) patients had abnormalities in the right upper lobe. In 30 (25%) patients, all fields of both lungs were affected. Also, 30 (25%) patients had HRCT findings in both left upper lobe and right lower lobe segments. Table 2 shows the frequency of HRCT findings regarding the various lung segments.

The patients were divided into three groups by age. The frequency of abnormalities was compared in different age ranges, but the difference between groups was not statistically significant (P = 0.9) (Table 3).

DISCUSSION

Mustard gas can have deleterious effects on the human body, among the most serious being respiratory effects. In the current study, 200 Iranian veterans with respiratory symptoms who were exposed to mustard gas during the Iran-Iraq War...
CONCLUSION

We found a high frequency of HRCT abnormalities among mustard gas-exposed veterans, and most abnormalities were irreversible. Therefore, we recommend that periodic pulmonary assessments be performed for these patients. In our study, HRCT findings included diffuse hyper-aeration, interstitial opacity, parenchymal opacity, bronchiectasis, sub-pleural air trapping, and local fibrosis. Other areas that warrant further study in terms of patient exposure to mustard gas include the cellular effects of mustard gas and genetic markers indicating exposure to mustard gas.

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AUTHOR CONTRIBUTIONS

All authors contributed equally in this study.

CONFLICT OF INTEREST

There are no conflict of interest.

ETHICAL STANDARDS

Informed consent was obtained from each participant. This study was approved by the ethics committee of Shahid Sadoughi University of Medical Sciences (number 1017).

REFERENCES


