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RESEARCH ARTICLE

Pathologic Findings of Anthraco-silicosis in the Lungs of One Humped Camels *(Camelus dromedarius)* and Its Role in the Occurrence of Pneumonia

Mehdi GOODARZI [1] Shahrzad AZIZI [2]
Mohamad Javaheri KOUPAEI [3] Saadat MOSHKELANI [4]

[1] Department of Clinical Sciences, School of Veterinary Medicine, Islamiac Azad University, Shahrekord Branch, Shahrekord - IRAN
[2] Department of Pathobiology, Faculty of Veterinary Medicine, Shahid Bahonar University of Kerman, Kerman - IRAN
[3] Graduated of Veterinary Medicine School, Islamic Azad University, Shahrekord Branch, Shahrekord - IRAN
[4] Young Researcher Club, Islamic Azad University, Shahrekord Branch, Shahrekord - IRAN

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Summary

Pneumoconiosis is an occupational lung disease which occurs by the accumulation of inhaled organic and inorganic particles in the pulmonary parenchyma. These particles interfere with the defense mechanisms of the lungs. This study was designed to describe the gross and histopathological features of pneumoconiosis in the lungs and its relation with occurrence of pneumonia in camels. 150 pneumonic and 100 healthy lungs were examined for pneumoconiosis in pathologic level. Macroscopic lesions of pneumoconiotic lungs were related to pneumonia and no remarkable features of pneumoconiosis were observed in the examined tissues. Pneumoconiosis was diagnosed in 43 out of 150 lungs with pneumonic lesions. Grossly healthy lungs did not show pneumoconiosis. Out of 43 pneumoconiotic lungs, 93% (n=40/43) were associated with interstitial pneumonia. Also, pneumoconiosis occurred in 2.32% (n=1/43) and 4.65% (n=2/43) of lungs with suppurative bronchopneumonia and bronchointerstitial pneumonia, respectively. Histopathologic findings related to pneumoconiosis were characterized by varying degrees of diffuse to nodular fibrosis as well as mild to heavy accumulations of mixed carbon and silicon dusts. Interlobular and interalveolar septa of alveoli were thickened by fibrosis and infiltration of mononuclear inflammatory cells. Crystalline silicon particles were in different shapes including filamentous, oblong and polygonal. Anthraco-silicosis particles were observed inside and outside of macrophages more adjacent to the vessels and bronchioles as well as lymphocytes infiltration. The color of particle aggregations was different from scant gray to brown or dense black, depending on the amount of silicon or carbon dust deposition. In the lungs, areas with prominent deposition of crystalline silica rather than carbon were gray to light brown and focal interstitial fibrosis was occurred. The present study suggests a positive causal relationship between pneumoconiosis and pneumonia. It seems these particles predispose animals to pulmonary diseases especially various type of pneumonia.

Keywords: *Pneumoconiosis, Pathology, Silicosis, Anthracosis, Camel*

Tek Hörgüçlü Develerde *(Camelus dromedarius)* Anrako-silikozisin Akciğerlerdeki Patolojik Bulguları ve Pömoni Oluşumundaki Rolü

Özet

Pnömokoniozis pulmoner parankimde solunan organik ve inorganik partiküllerin birikmesi ile oluşan bir akciğer hastalığıdır. Bu partiküller akciğerlerin savunma mekanizmalarını bozarlar. Bu çalışma develerde pnömokoniozisin makroskopik ve histopatolojik özelliklerini tanımlamak ve pnömoni oluşumu ile ilişkisini ortaya koymak maksadıyla yapılmıştır. Çalışmada 150 pnömonili ve 100 sağlıklı akciğer pnömokoniozis yönünden incelendi. Pnömokoniotik akciğerlerdeki makroskopik lezyonlar pnömoni ile ilişkilendirildi ve incelenen dokularda pnömokoniozisin belirgin hiçbir özelliği gözlemlenmedi. Pnömoni lezyonlu 150 akciğerden 43'ünde pnömokoniozis tespit edildi. Makroskopik olarak sağlıklı akciğerlerde pnömokoniozis gözlemlenmedi. 43 adet pnömokonitik akciğerin %93'ü (n=40/43) intersitisyal pnömoni ile ilişkili idi. Pnömokoniozis %2.32 oranında suppuratif pnömoni ile %4.65 oranında da bronkointersitisyal pnömoni ile gözlemlendi. Pnömokoniozis ile ilişkili histopatolojik bulgular diffuzdan nodülere değişen derecede fibrozis ve ortadan şiddetliye değişen oranda miks karbon ve silika tozlarının birikmesi ile karakterize idi. İnterlobular ve interalveolar septumlar fibrozis ve mononüklear yangı hücrelerinin infiltrasyonu ile kalınlaşmıştı. Kristalize silika partikülleri filamentöz, oblong ve poligonal şekilleri içeren değişik şekillerde idi. Antrako-silika partikülleri damar ve bronşiyol duvarlarına özellikle yakın olmak üzere makrofajların içinde ve dışında, lenfosit infiltasyonu ile birlikte gözlemlendi. Partikül birikintilerinin rengi açık griden kahverengi siyaha değişen renklerde silika ve kadron birikim miktarına bağlı olarak gözlemlendi. Akciğerlerde kadrondan daha ziyade silika kristallerinin belirgin birikimi olan alanlar gri açık kahverenginde olup fokal intersitisyal fibrozis ile birlikte gözlemlendi. Bu çalışma pnömokoniozis ve pnömoni arasında belirgin bir ilişki olduğunu ortaya koymaktadır. Bu partiküllerin çeşitli tip pnömonilere karşı predispoze ettiği kanısına varıldı.

Anahtar sözcükler: *Pnömokoniozis, Patoloji, Silikozis, Antrakozis, Deve*

İletişim (Correspondence)
+98 381 3361045
mg1380@yahoo.com

INTRODUCTION

Pneumoconiosis is an occupational lung disease which causes by the accumulation of inhaled particles in the pulmonary parenchyma. These particles escape from the mucociliary defense mechanisms of the upper respiratory systems and deposit in the alveoli. After phagocytosis of particles by pulmonary macrophages, they are transferred to the peribronchial and perivascular regions [1,2]. These particles persist within the macrophages and induce a tissue reaction in the lungs by stimulating inflammatory mediators [2]. Pneumoconiosis may be clinicopathologically classified as fibrotic (lead to nodular or diffuse fibrosis) or nonfibrotic (including particle-laden macrophages, with minimum or no fibrosis) [3]. Some subgroups of pneumoconiosis such as silicosis, anthracosis or coal worker pneumoconiosis, asbestosis, berylliosis, and talcosis are fibrotic forms of pneumoconiosis. Siderosis (from iron oxide), stannosis (from tin oxide), and baritosis (from barium sulfate) are nonfibrotic forms of the disease [4]. Anthracosis or black pigment discoloration causes by coal dusts or environmental pollutions. Lungs and regional lymph nodes are target tissues. In human, extrathoracic anthracosis are rarely reported in the esophagus [5] and liver [6]. This condition is more common in human than animals because they are not in exposure to the occupational conditions in contrast to human cases [2,7]. In animals, Mild pulmonary anthracosis is a common incidental finding in crowded city or those cohabite with cigarette smokers. Also, those animals living in the desert have pneumoconiosis and crystals accumulate be more with increasing the age [8]. Therefore, spontaneously occurring pneumoconiosis in the animals is rarely reported [2,8]. This study describes the gross and histopathological features of pneumoconiosis in the lungs and its relation with the occurrence of pneumonia in camels.

MATERIAL and METHODS

Sample Collection

This study was performed in the local abattoir of Najaf-Abbad, Esfahan province, central part of Iran from November 2010 to April 2011. In this abattoir, ruminants including sheep, goat, cow and camels are slaughtered daily. The camels originated from east, south and south east parts of Iran that these areas have warm, dry and windy weather. For this study, 150 lungs of slaughtered camels with macroscopic pneumonia lesions and 100 apparently normal lungs (2 to 7 years old) inspected and some specimens of the lungs were taken for histopathologic study.

Pathological Investigation

The collected samples in 1 cm^3 thicknesses of the pneumonic and normal lungs were fixed in 10% neutral buffered formalin for histopathological examination. The samples were then dehydrated in graded ethanol and embedded in paraffin. Sections of 5 µm in thickness were stained with hematoxylin and eosin and then, examined by an ordinary light microscopy.

RESULTS

In this study, pneumoconiosis was diagnosed in 43 out of 150 lungs with the pneumonic lesions in histopathologic level and the apparently healthy lungs did not show any deposition of particles in the parenchyma. Observed macroscopic lesions of the affected lungs were related to pneumonia and no remarkable features of pneumoconiosis were visible in the examined tissues. Out of 43 pneumoconiotic lungs, 93% (n=40/43) were associated with interstitial pneumonia. Affected lungs were enlarged, rubbery in consistency, diffusely red to pale appearance and rib impressions were seen on the costal surfaces of the diaphragmatic lobes. They failed to collapse with pressure and no evidence of exudates was detected in the cut surfaces and airways *(Fig. 1)*. Also, pneumoconiosis was occurred in 2.32% (n=1/43) and 4.65% (n=2/43) of lungs with suppurative bronchopneumonia and bronchointerstitial pneumonia respectively. The lungs with suppurative pneumonia showed consolidation of the cranioventral and accessory lobes. The affected lobes were dark red with firm consistency *(Fig. 2)*.

Histopathologic findings of pneumoconiosis were characterized by varying degrees of diffuse to nodular fibrosis associated with mild to heavy accumulations of mixed carbon and silicon dusts. Diffuse interstitial fibrosis was prominent feature. Interlobular and interalveolar

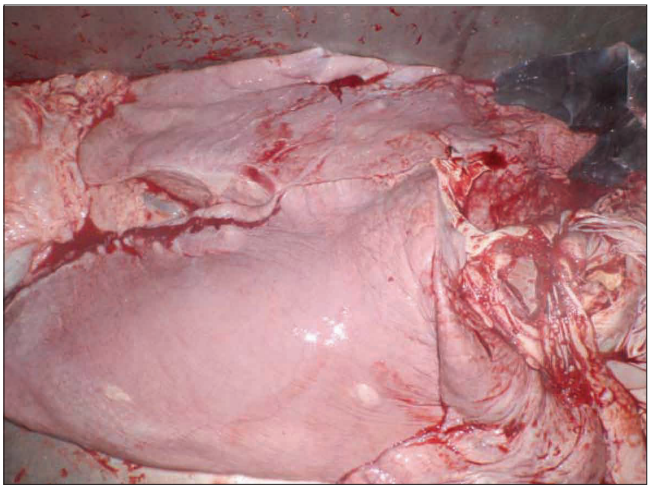


Fig 1. Macroscopic appearance of interstitial pneumonia. Affected lungs are enlarged, pale and uncollapsed

Şekil 1. İntersitisyal pnömoninin makroskopik görüntüsü. Akciğerler büyümüş, açık renkli ve kollabe olmamış

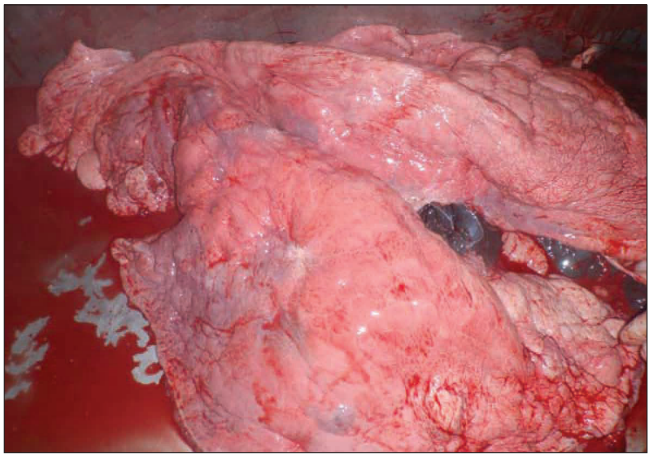


Fig 2. Macroscopic appearance of suppurative bronchopneumonia showed consolidation of the cranioventral and accessory lobes

Şekil 2. Kranioventral ve aksesor loblarda konsalidasyon ile karakterize Suppuratif bronkopnömoninin makroskopik görüntüsü

septa of alveoli were thickened by fibrosis and infiltration of mononuclear inflammatory cells. Emphysema and atelectasis were visible. Anthraco-silicosis particles were observed inside and outside of macrophages more adjacent to the vessels and bronchioles as well as lymphocytes infiltration (*Fig. 3* and *Fig. 4*). The color of anthraco-silicosis particles had variety from scant gray to brown or dense black, depending on the amount of silicon or carbon dust. Silicon particles were crystalline in different shapes including filamentous, oblong and polygonal *(Fig. 5)*. The areas with prominent deposition of crystalline silica rather than carbon were gray to light brown and focal interstitial fibrosis was occurred. In suppurative bronchopneumonia, in addition pneumoconiosis lesions, neutrophil-rich exudates were noted in the alveolar spaces and lumens of the airways, and in some occasions an admixture of cell debris, mucus, fibrin, and macrophages were observed in these areas.

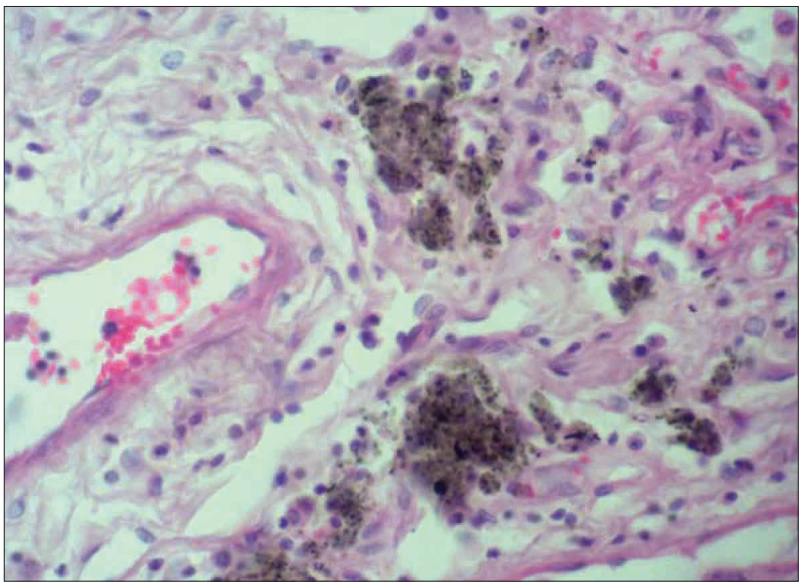
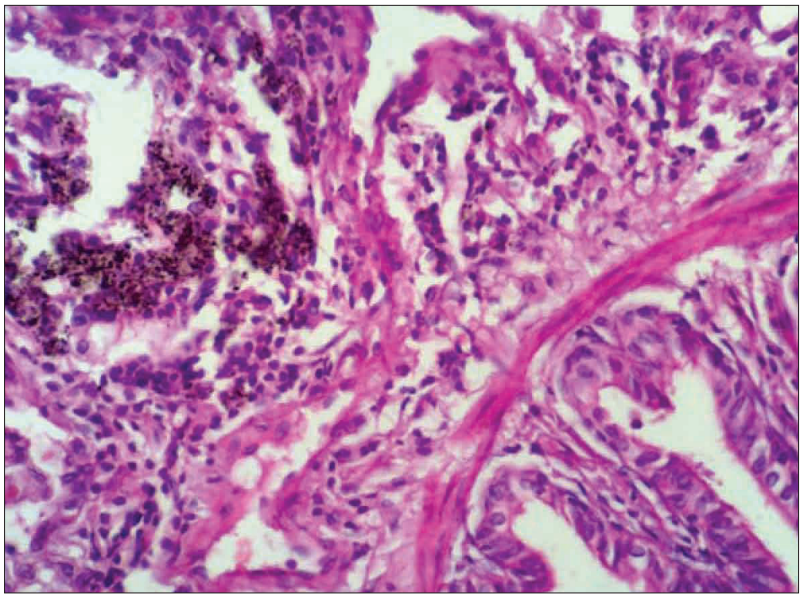


Fig 3. Histopathologic section shows black color of pulmonary parenchyma due to deposited carbon in the cytoplasm of macrophages and free in the parenchyma with fibrosis and lymphocytes infiltration adjacent to the vessel (H and E, ×400)

Şekil 3. Makrofajların sitoplazmasında ve boşlukta karbon birikimi nedeniyle pulmoner parankimde siyah renk ve fibrozis ile birlilkte dammar duvarına yakın lenfosit infiltrasyonu

Fig 4. Peribronchiolar deposition of carbon particles associated with lymphocytes infiltration (H and E, ×400)

Şekil 4. Lenfosit infiltrasyonu ile birlikte peribronşioler karbon partiküllerinin birikimi (HE, ×400)



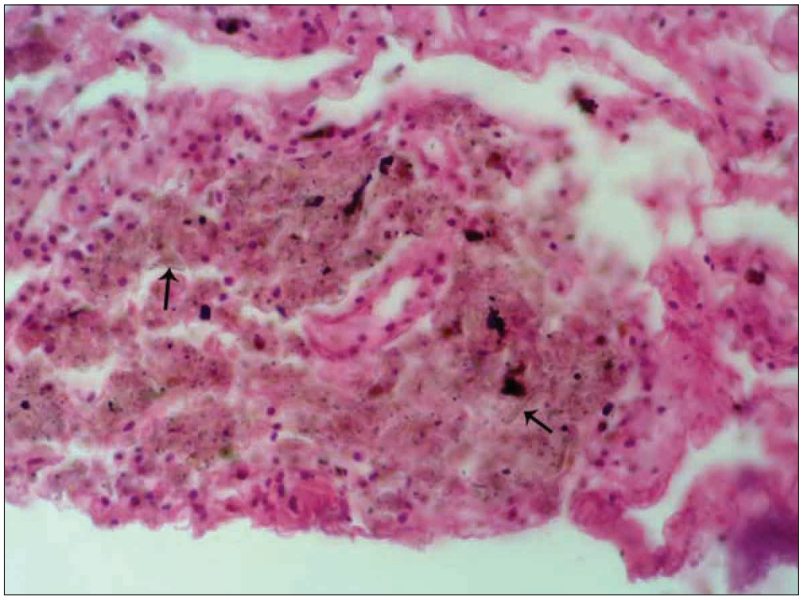


Fig 5. Gray to light brown pulmonary tissue due to crystalline silicon particles in different shapes including filamentous, oblong and polygonal (arrows) (H and E, ×400)

Şekil 5. Filamentöz, oblong ve polygonal şekilleri içeren değişik şekillerde kristal silika partikülleri nedeniyle gri açık kahverengindeki pulmoner doku

DISCUSSION

Accumulation of organic and inorganic particles in the pulmonary parenchyma causes a disease named pneumoconiosis [1,9]. Silicosis, antharcosis, and asbestosis are the most common types of pneumoconiosis, whereas siderosis, berylliosis, stannosis, and baritosis are uncommon forms [4]. Anthracosis and silicosis are terms that used for lesions induced by deposition of carbon and silicon in affected tissues. Carbon originates from coal mines, smoking, air pollution and fuels used for general usages such as cooking or home heating [10-13]. The breathing of fine crystalline silicon dioxide (silica) leads to pulmonary silicosis [14]. Occupational conditions such as mining, quarrying, and tunneling are associated with silicosis [15].

In animals, pneumoconiosis is not common and considerable. Those animals such as camels that live in arid or desert areas are in exposure to atmosphere rich in silicates due to bellowing the "sand wind" in deserts and carry a lot of dust particles into the respiratory system. Silica causes aggressive pneumoconiosis with fibrotic and nodular lesions [8].

Previously, the pathologists had belief that the carbon dusts are neutral and harmless pigments. Nowadays, it is demonstrated that carbon lead to fibro-inflammatory response in the tissues alone or in combination with other dust particles such as silica which causes anthraco-silicosis [16]. In human, anthracosis causes the obstruction of the large bronchioles and can make severe respiratory symptoms including dyspnea, coughing and susceptibility to infections [17]. Although, anthracosis has usually used for coal miners and rarely in city dwellers, but the experiences of some physicians have shown infectious diseases and malignancies are implicated in a background of anthracosis [18].

Diagnostic techniques for pneumoconiosis are including radiography and observation of small rounded or irregular opacities by chest X-rays and computed tomography (CT) [4,9]. Anthracosis can be recognized simply by light microscope as black-colored pigments along the respiratory airway or lymph nodes [19]. The minerals could be visible as birefringent crystals by polarized light [1].

In the present study, anthraco-silicosis was detected in 43 (28.7%) of 150 pneumonic lungs of slaughtered camels. The most common pneumonia associated with pneumoconiosis was interstitial pneumonia and then, bronchointerstitial and suppurative bronchopneumonia. Gross lesions related to anthraco-silicosis were not evident. Histopathologic lesions were different from diffuse to focal pulmonary fibrosis and mixed pigments of carbons and silicons. These particles were inside the cytoplasm of macrophages or as extracellulary around the bronchioles and vessels and, lesser in the pulmonary parenchyma. In the areas with prominent deposition of crystalline, affected tissues showed gray to light brown color and focal interstitial fibrosis.

Bekele [20] identified pneumoconiosis in the lungs and associated lymph nodes of 36 (34.62%) camels. Microscopic examination of lesions was varied from focal aggregates of dust-laden macrophages with diffused fibrosis (58.1%) to fibrous granuloma (41.9%). The fibrous granulomas were as firm nodules on palpation that located deeply in the lung parenchyma. About 48.4% of the pneumoconiotic lesions in the lungs were associated with the peribronchiolar or perivascular fibrosis and 39% revealed chronic pleuritis. 36.11% and 8.33% of pneumoconiotic lungs had emphysema and bronchopneumonia respectively. Aggregations of dust-laden macrophages were also visible in the bronchial lymph nodes. This researcher described that pneumoconiosis is a common environmental dangerous health that predisposes camels to secondary infections. These particles cause peribronchiolar fibrosis

and granulomas that disturb the normal airflow of the conducting systems and interfere with the defense mechanisms of the lungs [20]. This point is in agreement with the present study that pneumoconiosis was associated with the pneumonic lungs especially interstitial pneumonia and did not observe in the normal ones. In the previous reports of pneumoconiosis in camels, described pathologic features were similar to our results. Also, in a study by Hansen *et al*.[21] chronic interstitial pneumonia and fibrosis were observed in the pneumoconiotic lungs.

Xuanren [22] studied pneumoconiosis in the lungs and regional lymph nodes of 48 Bactrian camels by the light and electron microscope, electronic probe microanalysis technique and the mineralogical analysis. Pneumoconiosis lesions were diagnosed only in the lungs (n=13) and, the lungs with the regional lymph nodes (n=35). The pulmonary lesions were characterized by multifocal interstitial pneumonia with accumulation of dust laden macrophage. In the lymph nodes, affected cells showed the vacuolar mitochondria, swollen endoplasmic reticula and completely damage of the cytoplasmic organelles. Dust particles were mainly composed of aluminium silicate, the main substances of the sand dusts. They concluded that the camels may expose to sand dust particles for a long time and suffer from aluminium silicate pneumoconiosis [22]. Similar results were reported in a study on pneumoconiosis in camel by Zliuo *et al*.[23].

Beytut [24] studied gross and histopathological findings of anthracosis in lungs and local lymph nodes of sheep and its potential role in the occurrence of pneumonia in Turkey. Anthracosis was diagnosed in the lungs and regional lymph nodes of 45 (2.25%) out of 2000 sheep. Grossly, only 12 (26.6%) out of 45 antharcotic lungs showed patchy areas of dark red consolidation in the caudal and cranial lobes. No prominent pigmentation was detected in the other pneumoconiotic lungs. The lymph nodes were greyish to black in appearance. In histopathlogic examination, similar to the present study, focal accumulation of carbon-laden alveolar macrophages had been visible mainly around the terminal respiratory bronchioles. The cytoplasm of sinusoidal macrophages located in the medulla of the lymph nodes filled with phagocytized particles.

Özcan & Beytut [25] reported pneumoconiosis in 3.85% (n=27/700) of lungs and regional lymph node of slaughtered cattle in Turkey. In the lungs, black pigments areas observed grossly on the pleural surface and around the bronchioles bifurcation. Also, entire surface of the local lymph nodes were covered by carbon pigments. In agreement with our study, carbon particles accumulated freely in the peribronchiolar and perivascular tissues or in the cytoplasm of macrophages. Polluted environments impair the alveolar clearance and cause peribronchiolar and perivascular deposition of particles [1]. Perillo *et al*.[26] described lesions due to minerals deposition in the lung and regional lymph nodes of 60 out of 183 slaughtered cattle. Alveolar septa were thickened and foci of fibrosis and bronchopulmonary inflammation occurred. Silicon, aluminium, titanium, iron, carbon and small quantity of the other metals were detected by energy-dispersive X-ray microanalysis. They concluded that the cattle living in the polluted areas may be helpful in estimation of the environmental contaminants risk for human in exposure.

Roperto *et al*.[27] described silicate pneumoconiosis in 4 pigs lived near chalk quarries. The pulmonary lesions were comprised of the thickened alveolar septa and small foci of initial fibrosis. Free and intracytoplasmic dusts were present in the bronchiolar, alveolar and interstitial tissues. An energy dispersive X-ray microanalysis with a scanning electron microscope detected that these dust were composed mainly of silicon, calcium, potassium, sulphur, aluminium and iron. The same elements were found in the local lymph nodes. These researchers stated that domestic animals in polluted environments are an important biological source that gives helpful data for evaluation of human health risks.

Similar to pneumoconiosis in animals, nodular fibrosis adjacent to the vessels and bronchioles were reported in human [28-30]. In patients affected with coal worker pneumoconiosis, two morphologic features including coal macules and progressive massive fibrosis were observed. The size of coal macules ranged from 1 to 5 mm and was characterized by solid anthracotic pigmentation without intervening fibrotic tissue. Progressive massive fibrosis was identified by the presence of a fibrotic mass with diameter of more than 1 cm and carbon pigmentation. The fibrotic masses were constructed of arranged collagen with numerous pigment-laden macrophages and a lot of free pigments especially in their central regions [31,32]. Coal dusts inhalation lead to chronic obstructive pulmonary disease and ultimately death in patients [33,34]. Also, the risk of tuberculosis increases in coal worker pneumoconiosis [33]. Brambilla *et al*.[8] described that deposited crystals are associated with different pulmonary lesions, eg, pneumonia.

In animals, only clinically important pneumoconiosis is silicosis in horses and, rarely, dogs. It occurs in certain geographic areas with the soil containing crystalline silica. Particles in 0.5-5 µm size are the most likely particles that trappe in the distal airways, and filamentous particles are more injurious than amorphous ones. The clinical signs are including exercise intolerance, weight loss, and dyspnea. Miliary lesions are distributed throughout the lungs, and consist of fibrosis containing multifocal granulomatous with necrosis and mineralization in their centers. Birefringent, eosinophilic, or brown crystals are not clearly visible in the affected tissues. They are detectable by electron microscopy and X-ray spectroscopy [2].

The present study suggests a positive causal relationship between pneumoconiosis and occurrence of pneumonia. It seems these particles predispose animals to

pulmonary diseases especially various types of pneumonia. Further researches are necessary for understanding the pathogenesis of various particles and their effects on immune system of the lungs and occurrence of pulmonary diseases.

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