Original Article

Clinical statistics analysis on the characteristics of pneumoconiosis of Chinese miner population

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Background: Pneumoconiosis is one of the most common occupational diseases, which shows the progressive and irreversible pathological changes. It ultimately can induce pulmonary failure and lead to death. To date, these patients have no curative treatment option under the current standard of care, so it is especially important to delay the onset of the disease and slow down its progression. Therefore, understanding of clinical features of pneumoconiosis is particularly critical for medical intervention.

Methods: We collected the clinical data from 118 pneumoconiosis cases of miners admitted in hospital and processed the statistics analysis by using the Chi-square test and the risk assessment.

Results: Compared to other types of miners, gold miners are liable to cause Broncho-pulmonary co-infection with Chi-square value 18.748 and the P value <0.001. However, unexpectedly, the smoking miners displayed a better Activities of Daily Living (ADLs) compared to non-smokers, which showed 19.318 of Chi-square score and less than 0.001 of P value. And this connection was associated with the dust exposure time ($P<0.05$), showing the increasing risk of non-smoking miners occurred as the increasing time exposed to dust. In addition, our analysis indicated that the probability of smoking miners suffered from Broncho-pulmonary co-infection was less than non-smoking miners with Chi-square value 8.044 and $P<0.01$, which was also associated with the dust exposure time tendentiously, though $P>0.05$. Moreover, smoking history exhibited a deteriorating effect to the overall survival (OS) with 9.546 of Chi-square value and $P<0.05$, in accordance with smoking reducing life time. Interestingly, pneumoconiosis drugs could extend the smokers' OS, but not non-smokers'.

Conclusions: Our studies suggest that the history of smoking and exposure time of dust play important roles in the development of pneumoconiosis and smoking could be a factor that determines the treatment options depending on patients' smoking history.

Keywords: Pneumoconiosis; epidemiology (EP); prevention & control (PC)

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Introduction

Pneumoconiosis is one of the most common diseases in the miners, which is characterized by the progressive and irreversible pathologic features. The main cause of this disease is the excessive inhalation of dust in working process, which can lead to repeated inflammation, progressive pulmonary fibrosis, reducing the patients' survival time, lung function failure and eventually cause death (1).

Epidemiological investigation on the global lung diseases showed that the prevalence of pneumoconiosis ranked the top of occupational lung diseases, especially in developing countries, where this phenomenon is more serious (2). Chinese is one of populations exposed to dust most widely with the highest prevalence of pneumoconiosis every year (3,4). According to the reports of 2014 National Occupational Disease published by National Health and Family Planning Commission (NHFPC) of the People's Republic of China, there were 29,972 new cases of occupational lung diseases diagnosed in 2014, 90% of which was pneumoconiosis, namely 26,873 cases. When classified by types of jobs, coal mining, washing industry and non-ferrous metal mining industry were ranked the top three with 11,396 cases, 2,935 cases and 4,408 cases, respectively, accounting for 62.52% of all new diseases (5). The direct economic loss for the country reached 8 billion per year, and the indirect economic losses even reached 20 billion (6,7).

However, the pneumoconiosis is still not curable as there is no effective treatment or control drug to slow down the disease progression. Currently the most effective way to retard the disease is prevention. Studies have shown that reducing the worker's daily breathing concentration of dust can effectively reduce the chance of suffering from pneumoconiosis (8,9). According to the rules of American Conference of Governmental Industrial Hygienists (ACGIH), they defined the dangerous levels of work conditions by a clear principle on working hours and dust concentration. And more specifically, the dangerous levels were different from each type of dust because the maximum allowable levels were different (10,11). The methods currently applied to control the concentration of dust are: technological innovation, wet field operations, ventilation dust, individual protective equipment, occupational health management, health education, monitoring and inspection (12).

With the rapid development of economy and industry, and the insufficient protection of the environment, there are more than 6 million underground mining workers under the threat of Pneumoconiosis in China (13). So the financial burden for initiating preventive efforts is extremely serious (14). Therefore, it is very essential to learn the basic condition of pneumoconiosis patients, effectively find out the characteristics of Chinese miners' pneumoconiosis, and develop effective treatment strategies to prevent and control this illness.

In this study, we have collected patient information of 118 clinical cases from the Taihe Hospital. We analyzed the clinical data of pneumoconiosis patients by using the statistical methods of the Chi-square test, the multilayer Chi-square test and the risk ratio (RR) test, and identified the characteristics of this disease to develop useful prevention and treatment strategies for the clinical patient care.

Methods

Basic subjects

According to the diagnostic criteria of pneumoconiosis (15,16), 118 pneumoconiosis patients (117 males and 1 female) from Taihe Hospital were retrospective analyzed since 2010, and 50 (42.4%) of coal miners, 19 (16.1%) of gold miners, 12 (10.2%) of mixer of both and 37 (31.4%) of other miners were included. According to lung imaging diagnosis of pneumoconiosis patients (16), there were 18 (15.3%) patients in stage I, 83 (70.3%) in stage II, and 17 (14.4%) in stage III, who were diagnosed when first admitted to Taihe hospital. We also classified these patients into different groups: groups according to age, <50 years old of 83 (70.3%) and >50 years old of 35 (29.7%); groups according to smoking history, 55 (46.6%) of smokers and non-smokers of 63 (53.4%). In addition, they were divided by dust exposure time: 16 (13.6%) <3 years, 17 (14.4%) between 3–5 years, 41 (34.7%) between 5–10 years, and 44 (37.3%) >10 years. Among them, except one patient without any treatment, 15 (12.7%) of these patients were treated with drugs specifically used for pneumoconiosis, 22 (18.6%) of them were subjected to lung lavage therapy, and combination of both treatments applied to other 80 (67.8%) patients. The study protocol was approved by the Department of ethnics committee, Shiyan Taihe Hospital (ID: 2016001-1) and was conducted in accordance with the Helsinki Declaration of 1964 (revised 2008).

Observation subjects

To learn the pathological characteristics of pneumoconiosis, manifold investigation and observation were included in this

Table 1 Risk assessment and comparison between Broncho-pulmonary co-infection history and types of miners in different conditions

Basic and observation subjects	Broncho-pulmonary co-infection history								BD value[b]
	>3 times/year				<3 times/year				
	Gold miner	Coal miner	Mixer[a]	Other miners	Gold miner	Coal miner	Mixer[a]	Other miners	
Ages									P>0.05
<50 years old	7	5	2	6	9	26	7	21	
>50 years old	2	2	0	0	1	17	3	10	
Dust exposure time									P>0.05
<3 years	1	0	0	1	0	5	1	8	
3–5 years	1	1	0	0	3	7	0	5	
5–10 years	3	3	1	2	3	19	2	8	
>10 years	4	3	1	3	4	12	7	10	
Treatments									P>0.05
Drugs[c]	2	1	0	1	1	6	1	3	
Lung lavage	3	0	0	1	2	8	3	5	
Combination[d]	4	6	2	4	7	29	6	22	
Total number (percentage of all)	9 (7.6%)	7 (5.9%)	2 (1.7%)	6 (5.1%)	10 (8.5%)	43 (36.4%)	10 (8.5%)	31 (26.3%)	
F/χ^2	18.748 (P=0.005)								
RR[e] (95% CI[f])	–	0.181 (0.053–0.603)[g]	0.222 (0.045–1.298)[g]	0.215 (0.061–0.754)[g]	–	–	–	–	

RR, risk ratio. [a], mix of coal and gold mine; [b], Breslow-Day P value (test of conditional independence); in this table, because of the quadruple-observation objects, it cannot provide exact P value; [c], drugs specifically used for pneumoconiosis; [d], combination of drugs and lung lavage; [f], confidence interval; [g], risk ratio of co-infection >3 times/year compared to gold miner.

study: overall survival (OS), Activities of Daily living (ADLs, a term used in healthcare refer to people's daily self-care activities, which was classified into two phases in this research: living independently and living with help) (17), smoking history, syndromes including concurrent tuberculosis, concurrent hemoptysis, pneumothorax and Broncho-pulmonary infection cases. Patients signed an informed consent, and their other personal information will not be published to protect patient privacy.

Diagnostic criteria

According to the China National pneumoconiosis diagnostic criteria, pneumoconiosis patients should have dust exposure history records and appropriate chest X-ray examination (18).

Statistical analysis

Because the diagnosis time could not correspond to the real disease time, the initial exposure time to dust was used as a statistical target. All the statistical analysis procedures were performed by using SPSS 22.0 (SPSS Institute, Inc., Chicago, IL, USA). Differences between different groups of patients were accessed by using Chi-square tests assuming variances. In addition, a further analysis was performed by the multilayer Chi-square test to confirm the conditional independence with the Breslow-Day value. P values of less than 0.05 (2 tailed) are considered significantly different (19,20). Finally, the risk assessment of patients was predicted by using the RR test, and it is considered statistical significance as the ratio deviated from 1, more deviation and more difference.

Results

We compared types of miners with different syndromes including concurrent tuberculosis, concurrent hemoptysis, pneumothorax and Broncho-pulmonary infection by using Chi-square tests, and we found that gold miners are liable to cause Broncho-pulmonary co-infection with Chi-square value 18.748 and the P value <0.001 (*Table 1*). Moreover,

Table 2 Risk assessment and comparison between smoking history and ADL in different conditions

Basic and observation subjects	ADLs				BD value
	Living independently		Living with help		
	Smoker	Non-smoker	Smoker	Non-smoker	
Jobs					P=0.118
Gold mine	2	1	2	14	
Coal mine	16	1	18	15	
Mix	2	0	2	8	
Other mine	4	6	9	18	
Ages					P=0.696
<50 years old	16	6	22	39	
>50 years old	8	2	9	16	
Dust exposure time					P=0.038
<3 years	1	2	8	5	
3–5 years	4	2	5	6	
5–10 years	11	2	11	17	
>10 years	8	2	7	27	
Treatments					P=0.972
Drugs	2	1	3	9	
Lung lavage	5	1	7	9	
Combination	17	6	21	36	
Total number (percentage of all)	24 (20.3%)	8 (6.8%)	31 (26.3%)	55 (46.6%)	
F/χ^2	19.318 (P=0.004)				
RR (95% CI)	5.323 (2.136-13.266)[a]	–	–	–	

[a], risk ratio of living independently compared to non-smoker. ADLs, Activities of Daily.

a further risk assessment predicted that the risk of gold miners suffered from Broncho-pulmonary co-infection was almost 5 times more than other types of miners (*Table 1*). In addition, we compared various types of miners with Broncho-pulmonary co-infection in different conditions of multiple factors, including ages, dust exposure time and therapeutic methods by using multilayer Chi-square test, which showed no statistical significance with P>0.05 (*Table 1*).

Because of its specificity, smoking has been one of the key elements of clinical concern in lung diseases. Statistical analysis exhibited that lung functions of smokers declined faster with the increasing smoking years compared to the non-smokers (21,22). Due to excessive dust exposure, progressive pulmonary fibrosis and pulmonary failure are easily appeared in miner patients following pathological changes. To determine whether smoking could worsen pneumoconiosis of miners, we analyzed the clinical data of smoking history and their ADLs. However, unexpectedly, the smoking miners displayed a better ADLs compared to non-smokers, which showed 19.318 of Chi-square score and less than 0.001 of P value (*Table 2*). About 20.3% (24/118) of smokers lived independently compared to 6.8% (8/118) of non-smoking miners, which showed significantly different by using Chi-square tests. Moreover, the risk assessment exhibited non-smokers had 5 times more risk with worse ADLs compared to smokers (*Table 2*). We found that this connection was associated with the dust exposure time with P<0.05, analyzed by a further multilayer Chi-square test in various conditions, including jobs, ages, dust exposure time and treatments (*Table 2*). An additional risk assessment indicates that the increasing risk of non-smoking miners occurred as the increasing time exposed to dust (*Table 3*). The RR value was rising sharply year by year, which was up to 15.429 after exposing to dust more than 10 years, whereas it was only 0.313 when exposure time was less than 3 years.

Next, we studied the connection between smoking

Table 3 Risk assessment between smoking history and ADLs under different exposure time to dust

Dust exposure time	<3 years		3–5 years		5–10 years		>10 years		Total	
	Smoker	Non-smoker	Smoker	Non-smoker	Smoker	Non-smoker	Smoker	Non-smoker	Smoker	Non-smoker
ADLs (%)										
Living independently	1 (11.1)	2 (28.6)	4 (44.4)	2 (25.0)	11 (50.0)	2 (10.5)	8 (53.3)	2 (6.9)	24 (43.6)	8 (12.7)
Living with help	8 (88.9)	5 (71.4)	5 (55.6)	6 (75.0)	11 (50.0)	17 (89.5)	7 (46.7)	27 (93.1)	31 (53.4)	55 (87.3)
Total	9 (100.0)	7 (100.0)	9 (100.0)	8 (100.0)	22 (100.0)	19 (100.0)	15 (100.0)	29 (100.0)	55 (100.0)	63 (100.0)
RR (95% CI)	0.313 (0.022–4.413)[a]	–	2.400 (0.303–19.041)[a]	–	8.500 (1.574–45.916)[a]	–	15.429 (2.659–59.534)[a]	–	5.323 (2.136–13.266)[a]	–

[a], risk ratio of living independently compared to non-smoker.

Table 4 Risk assessment and comparison between Broncho-pulmonary co-infection history and smoking history in different conditions

Basic and observation subjects	Broncho-pulmonary co-infection history				BD value
	<3 times/year		>3 times/year		
	Smoker	Non-smoker	Smoker	Non-smoker	
Jobs					P=0.777
Gold mine	3	7	2	5	
Coal mine	32	11	1	8	
Mix	4	6	0	2	
Other mine	11	20	2	4	
Ages					P=0.450
<50 years old	34	29	4	16	
>50 years old	16	15	1	3	
Dust exposure time					P=0.604
<3 years	8	6	1	1	
3–5 years	8	7	1	1	
5–10 years	20	12	2	7	
>10 years	14	19	1	10	
Treatments					P=0.176
Drugs	5	6	0	4	
Lung lavage	12	6	0	4	
Combination	33	31	5	11	
Total number (percentage of all)	50 (42.4)	43 (36.4)	5 (4.2)	19 (16.1)	
F/χ^2	8.044 (P=0.039)				
RR (95% CI)	–	–	0.232 (0.682–0.080)[a]	–	

[a], risk ratio of co-infection >3 times/year compared to non-smoker.

history and other co-infection diseases, including concurrent tuberculosis, concurrent hemoptysis, pneumothorax and Broncho-pulmonary infection. As a result, our analysis indicates that the probability of smoking miners suffered from Broncho-pulmonary co-infection was less than non-smoking miners with Chi-square value 8.044 and P<0.01 (*Table 4*). About 16.1% (19/118) of smoking miners co-infected with Broncho-pulmonary, showing a significantly different compared to 4.2% (5/118) of non-smokers, which was not related with other factors, such as jobs, ages and

Table 5 Risk assessment and comparison between smoking history and overall survival in different conditions

Basic and observation subjects	OS				BD value
	<5 years		>5 years		
	Smoker	Non-smoker	Smoker	Non-smoker	
Jobs					P=0.785
Gold mine	3	10	1	5	
Coal mine	31	13	3	3	
Mix[a]	4	7	0	1	
Other mine	9	17	4	7	
Ages					P=0.744
<50 years old	32	32	6	13	
>50 years old	15	15	2	3	
Dust exposure time					P=0.888
<3 years	8	5	1	2	
3–5 years	7	6	2	2	
5–10 years	18	11	4	8	
>10 years	14	25	1	4	
Treatments					P=0.048
Drugs	4	9	1	1	
Lung lavage	12	5	0	5	
Combination	31	32	7	10	
Total number (percentage of all)	47 (39.8)	47 (39.8)	8 (3.8)	16 (13.6)	
F/χ^2	9.546 (P=0.049)				
RR (95% CI)	–	–	0.500 (0.195–1.280)[b]	–	

[a], mix of coal and gold mine; [b], risk ratio of OS <5 years compared to non-smoker. OS, overall survival.

treatments (*Table 4*). A further risk assessment revealed that the RR of smoking patients suffered from Broncho-pulmonary co-infection was 0.232 times of non-smokers, which indicated that non-smokers may be susceptible to this co-infection. However, this result is quite different from the common sense that smoking and dust exposure can increase the probability of lung infection. Therefore, we further analyzed the conditions independence on this result by using multilayer Chi-square test, as dust exposure time played a critical role in the relationship between ADLs and smoking history (*Tables 2,3*). Although, there was no statistical significance on the condition of different dust exposure time, the trend still showed that with the increasing dust time, the non-smokers would have more probability to get Broncho-pulmonary co-infection (data not shown).

Finally, expectedly, smoking history exhibited a deteriorating effect to OS with 9.546 of Chi-square value and P<0.05 (*Table 5*), comparing 3.8% of smoking patients with 13.6% of non-smokers when OS time was more than 5 years. Moreover, the RR indicated that the non-smokers had 2 times of probability to reach more than 5 years of OS compared to smokers (*Table 5*). Further multilayer Chi-square tests revealed that the link between smoking history and OS was associated with therapeutic methods (*Table 5*). An additional risk assessment showed that pneumoconiosis drugs were more beneficial to the smokers for extending OS with RR of 2.252 (*Table 6*), implying that these drugs may have side effects to non-smokers and the drugs therapy may be not appropriate to them. Conversely, lung lavage therapy was better to non-smokers with RR of 0.500 (*Table 6*). Therefore, these results suggested that the patients with the smoking history should select pneumoconiosis drugs therapy alone, and non-smokers

Table 6 Risk assessment between smoking history and overall survival under different therapeutic methods

Treatments	Pneumoconiosis drugs		Lung lavage therapy		Combination of drugs and lavage		Total	
	Smoker	Non-smoker	Smoker	Non-smoker	Smoker	Non-smoker	Smoker	Non-smoker
OS								
>5 years	1 (20.0)	1 (10.0)	0 (0)	5 (50.0)	7 (18.4)	10 (23.8)	8 (14.5)	16 (25.4)
<5 years	4 (80.0)	9 (90.0)	12 (100.0)	5 (50.0)	31 (81.6)	32 (76.2)	47 (85.5)	47 (74.6)
Total	5 (100.0)	10 (100.0)	12 (100.0)	10 (100.0)	38 (100.0)	42 (100.0)	55 (100.0)	63 (100.0)
RR (95% CI)	2.252 (0.111–45.454)[a]	–	0.500 (0.269–0.929)[a]	–	0.723 (0.244–2.137)[a]	–	0.500 (0.195–1.280)[a]	–

[a], risk ratio of OS <5 years compared to non-smoker.

should choose lung lavage therapy alone.

Discussion

In 1987, China enacted and implemented a principle entitled "*Pneumoconiosis disease prevention and disease control of the People's Republic of China*", and in 2001 another principle was promulgated: "*Occupational disease prevention and control of the People's Republic of China*" (23). Although the laws permit the acceptable dust concentration of 1 mg/m^3 and provide the methods to reduce dust concentration, the prevalence of pneumoconiosis in China has not yet significantly reduced due to the rapid economic and industrial development. Therefore, understanding of the characteristics of pneumoconiosis is particularly critical to effectively control the progress of the pneumoconiosis. Here we compared and analyzed the clinical data of 118 pneumoconiosis cases from the Taihe Hospital, which included all kinds of patients with different treatment options, co-infection history, age, dust exposure times, smoking history, working condition and ADLs.

Compared to other types of miners, gold miners are liable to cause Broncho-pulmonary co-infection (*Table 1*). Therefore, it is important to strictly control the dust concentration especially in the gold mine area, build and raise self-protection awareness of miners, and increase the chances of physical examination, which will be helpful to lower the morbidity of pneumoconiosis as well as medical expenses. In traditional Chinese medicine science, the pneumoconiosis is considered as a type of chronic diseases, and the dust as a dryness factor could block the main and collateral channels of lung, ultimately leading to the Qi and Yin deficiency in the body. Consequently, to investigate the treatment of Chinese medicine will be beneficial to invigorate the primordial Qi and Yin and improve physical health, such as Bu Zhong Yi Qi formula, Sha Shen Mai Dong formula (24) and tetrandrine (25).

Smoking is one of the common factors leading to pneumonia. The relationship between pneumoconiosis and smoking history could be a critical factor affecting the medical advice and treatments (26). Unexpectedly (27), our analytical data indicated that there was a negative correlativity between smoking history and Broncho-pulmonary co-infection, which showed that the probability of smoking miners suffered from Broncho-pulmonary co-infection was less than non-smoking miners (*Table 4*) which was concerned with the dust exposure time factor. Moreover, if the dust exposure time was less than 3 years, non-smokers kept better ADLs than the smoking miners. Reversely, as the increasing time exposed to dust, there was an increasing risk of non-smoking miners (*Table 3*). Unfortunately, the smoking miners' OS was still shorter than non-smokers (*Table 5*), in accordance with smoking reducing life time (28). Interestingly, pneumoconiosis drugs could only extend the smokers' OS, but not the non-smoking miners' (*Table 6*). One possibility is that these drugs could relieve the lung failure due to smoking and have side effects on non-smokers. Therefore, compared to these different treatments, we recommended that the patients with the smoking history should select pneumoconiosis drugs therapy alone, and non-smoking patients should choose lung lavage therapy alone without pneumoconiosis drugs.

In conclusion, the smoking history and dust exposure time play important roles in the progression of pneumoconiosis. However, the stage of disease as another factor need to be excluded if we want to confirm this conclusion. Co-infections often happened in stage III of pneumoconiosis, but the most patients admitted to the hospital were in stage II. Hence, we need to collect more stage III patients and observe their condition. Moreover, we will further focus on finding out the biological factors that may change the possibility of co-infection ratio in the different dust exposure time.

To date, there is no available treatment for pneumoconiosis provided by any institution or randomized controlled trail (RCT). The research on this disease is almost about the prevalence, risk assessment and clinical experiments. Dr. Wang chose six different Chinese medicine formulas to treat the pneumoconiosis, and observed the patients relief from the symptoms (24). Dr. Tao divided pneumoconiosis into four syndromes and gave different formulas. The two results above suggested that their therapies had efficacy, however, their experiments did not use randomized control method and not evaluated by statistical analysis. More probable, it is essential to set up a pneumoconiosis clinical research criterion to further study and treat this disease.

Here we found the fundamental properties of pneumoconiosis, but we still have a long way to go to prevent and control this disease, and the discovery of effective drugs and other efficient treatments appear especially important. Patients of stage II were dominated in this retrospective study, so further validation analyzes with more populations of other stages are needed to confirm our findings. In addition, more mechanism and functional study is needed to promote drugs development in the future.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: The study protocol was approved by the Department of ethnics committee, Shiyan Taihe Hospital (ID: 2016001-1) and was conducted in accordance with the Helsinki Declaration of 1964 (revised 2008). Patients signed an informed consent, and their other personal information will not be published to protect patient privacy.

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