

Case Report

A Case Report of Lung Cancer in a Horse Trainer Caused by Exposure to Respirable Crystalline Silica: An Exposure Assessment

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Here, we present a case of lung cancer in a 48-year-old male horse trainer. To the best of our knowledge, this is the first such case report to include an exposure assessment of respirable crystalline silica (RCS) as a quartz. The trainer had no family history of lung cancer. Although he had a 15 pack/year cigarette-smoking history, he had stopped smoking 12 years prior to his diagnosis. For the past 23 years, he had performed longeing, and trained 7-12 horses per day on longeing arena surfaces covered by recycled sands, the same surfaces used in race tracks. We investigated his workplace RCS exposure, and found it to be the likely cause of his lung cancer. The 8-hour time weight average range of RCS was 0.020 to 0.086 mg/m³ in the longeing arena. Horse trainers are exposed to RCS from the sand in longeing arenas, and the exposure level is high enough to have epidemiological ramifications for the occupational risk of lung cancer.

Key Words: Lung cancer, Quartz, Risk assessment

Introduction

While riding and longeing horses, trainers are exposed to inorganic dust arising from track sands and soils. Although most horse riding is done in open spaces, longeing is often done in indoor arenas. Crystalline silica, a causative agent of occupational and environmental lung cancer [1], is abundant in sands and soils. Horse trainers could therefore be exposed to crystalline silica dust from training surfaces. Oxidative stress and silica-induced DNA interactions could be generated when this dust is inhaled [2]. A high-enough exposure to respirable crystalline silica (RCS) increases the risk of lung cancer; however, the exposure level and lung cancer risk of RCS in dust derived from indoor arena sands has not been assessed thus far.

Our report of a case of lung cancer suspected to be caused by exposure to RCS, involving exposure assessment of RCS,

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could have important epidemiological ramifications for the management of a preventable lung cancer risk in horse trainers.

Case Report

A 48-year-old male horse trainer, previously healthy without any known disease of the pulmonary system, complained of cough for two months and worsening dyspnea. He had no family history of lung cancer. He did have a 15 pack/year cigarette-smoking history, but had stopped smoking 12 years prior to this presentation. Chest radiographs and computed tomographic images revealed lung nodules, and a pleural effusion in the left lower lobe. Biopsy confirmed adenocarcinoma of the left lower lobe and pleura. Positron emission tomography and magnetic resonance imaging showed metastasis to the brain. Chemotherapy and conservative management were performed, but the patient died 2 years after diagnosis.

Before his death, his workers' union requested an epidemiological survey to be conducted, to find a possible causative material of the lung cancer in this horse trainer. Our team, the Occupational Risk Assessment & Management (ORANGE) team of the Korea Workers' Compensation & Welfare Service, interviewed the horse trainer, and undertook a walk-through survey.

For the past 23 years, the subject had worked as a trainer of racehorses, and performed horse care (Fig. 1A), feeding, longeing (Fig. 1B), and canter-play. Longeing is a useful training method for relieving stress in horses, and improving the communication between humans and horses.

In this training, the horse is made to exercise in a circular path, at the end of a lead, and respond to commands from the trainer. Longeing requires 25 minutes for the training of

1 horse, and our subject trained 12 horses between 1989 and 1993. Since 1994, he worked with 7 horses per day, 5 days per week. The surface of the longeing arena was covered with recycled sand, identical to that used on racetracks. To prevent humans from inhaling the dust generated by longeing, the surface was watered by a sprinkler, beginning in 2003, but this was not done in winter, in order to prevent horses from slipping on the frozen surface. Canter-play, exercising the horse by riding at canter speed on an outdoor race track, takes 20 minutes per horse. Sometimes, the canter-play is done at a similar speed to a race. The horse trainer worked with 5 horses each day, 5 days per week for canter-play. He worked from 5:30 am to 3:00 pm. As we reviewed the occupational history of the horse trainer, we suspected that his lung cancer was caused by exposure to RCS. Therefore the ORANGE team undertook an exposure assessment of RCS in the longeing arena.

The surface sand in the longeing arena was ground using a Spex Mixer/Mill (8000D; Spex Industry, Edison, NJ, USA) for 20 minutes, in order to achieve an appropriate particle size distribution for sieving. The ground sample was wet sieved with ethanol through a 10 μm sieve, to produce the <10 μm fraction. The crystalline silica content of the surface sand was analyzed by X-ray diffraction (D8 Advance; Bruker Corporation, Ettlingen, Germany) according to standard material calibration method. The sand was composed of 80% quartz as crystalline silica. The exposure assessments of RCS were undertaken according to the National Institute for Occupational Safety and Health (NIOSH) method 0500 guidelines (total dust) and NIOSH method 7500 guidelines (respirable quartz) [3]. The airborne samples were collected on the polyvinyl chloride filters (5.0 μm , 37 mm) using high volume cyclones (GK2.69; BGI Inc., Waltham, MA, USA) as sampling heads, in combina-

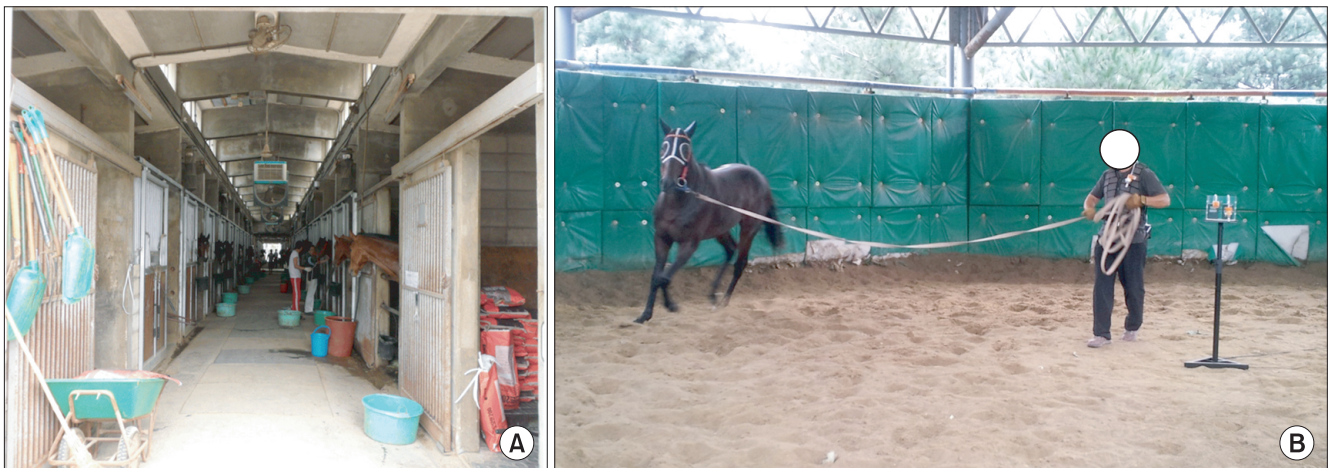


Fig. 1. (A) Feeding stable. (B) Longeing arena.

tion with sampling pump (AirChek XR5000; SKC Inc., Eighty Four, PA, USA) with a flow of 4.2 L/min. GK2.69 cyclones collect the respirable dust fraction, which is relevant in determining exposure to respirable quartz. Filters were weighed before and after sampling with a Mettler Microbalance (XP26; Mettler-Toledo, Greifensee, Switzerland). The analysis of quartz was performed by X-ray diffraction according to NIOSH method 7500. The 8-hour time-weighted averages (TWA) of the dust were analyzed for both area and personal samples. The 8-hour TWA of total dust and RCS during longeing were conservatively calculated, with the assumption that the exposure during all other working hours, including canter-play, is zero. The working hours were calculated assuming that he trained 7 horses per day, and spent 25 minutes on each horse.

The ORANGE team found that in 2012, the 8-hour TWA of total dust was 1.179 mg/m³ for the area sample and 1.623 mg/m³ for the personal sample. The 8-hour TWA of total dust was 5.060 mg/m³ for a personal sample, when analyzed by the Federation of Korean Trade Unions (FKT) in 2006.

The ORANGE team found that the 8-hour TWA of RCS for the area sample was 0.020 mg/m³, and that for the personal sample was 0.026 mg/m³ (Table 1). For the TWA of RCS in FKT, we used the assumption that the proportion of RCS in the total dust is the same for the ORANGE data and the FKT data. As there was no information on the RCS in personal sample 2 (FKT data), we used the data from personal sample 1 from the ORANGE data (showing that 1.7% of total dust is RCS). This yielded an RCS concentration of 0.086 mg/m³, through multiplying 1.7% and 5.060 mg/m³ (Table 1). The threshold limit value established by the American Conference of Governmental Industrial Hygienists (ACGIH) for RCS is 0.025 mg/m³. All RCS personal samples from the longeing arena were over the threshold limit value of the ACGIH.

Using the pooled exposure-response coefficient from 10 cohort studies generated by Steenland et al. [1], we estimated the lifetime excess risk of lung cancer at an age of 74 years with

exposure to 0.020, 0.026, and 0.086 mg/m³ RCS, with a 15-year lag time. These risks were 0.055%, 0.056%, and 0.068% for the 3 above-mentioned exposure levels, respectively. Furthermore, we estimated the lifetime excess risk of lung cancer at an age of 48 years, the age at which our current horse trainer was diagnosed, with a 15-year lag time. The excess lifetime risks were 0.077%, 0.078%, and 0.090%, respectively. The background lung cancer rates per 100,000 were 299.9 at the age of 75 years, and 7.8 at the age of 49, as reported in the Korean Statistical Information Service (available at www.kosis.kr/eng).

The horse trainer had been working for 23 years, since 1989, and his lung cancer was diagnosed in 2010. During the 23 years of longeing horses, he had been exposed to high levels of RCS, which were over the threshold limit value of the ACGIH. He was diagnosed with lung cancer at the relatively young age of 48, and died 1 year later; the lung cancer mortality of Korean males sharply increases after the age of 65 years [4]. Furthermore, the trainer's estimated excess lifetime risk of lung cancer was 0.077-0.090% from exposure to RCS working at the longeing arena, even if his other exposures to RCS were assumed to be zero, including canter-play. Therefore, the ORANGE team suggested that the lung cancer occurring in this horse trainer was an occupation-related disease.

Discussion

To the best of our knowledge, this is the first case report of lung cancer in a horse trainer that includes an exposure assessment of RCS. A trainer is exposed to RCS from the sands in the longeing arena, and the exposure level is high enough to have epidemiological ramifications for an occupational risk of lung cancer.

People engaging in horse care and feeding are exposed to organic dust, and this has been regarded as a hazardous occupation for respiratory diseases, such as chronic bronchitis, asthma, and organic dust toxic syndrome [5]. The exposure of

Table 1. Eight-hour time weighted level* of dust during longeing in indoor arena (unit: mg/m³)

Sample	Total dust	RCS	Percent of RCS in total dust
Area sample	1.179	0.020	1.7
Personal sample 1	1.623	0.026	1.6
Personal sample 2	5.060	0.086 [†]	-

The area sample and personal sample 1 were analyzed on 13 Jan 2012, and the total dust of the personal sample 2 was analyzed on 25 Jan 2006.

*Eight-hour time-weighted levels of dust during longeing were generated with the assumption that all other exposure totaled zero, and were calculated assuming that he trained 7 horses per day, spending 25 minutes on each horse.

[†]As there was no information on the respirable crystalline silica (RCS) in personal sample 2, we used the data from personal sample 1 (showing that 1.7% of total dust is RCS). This yielded an RCS concentration of 0.086 mg/m³.

horse trainers to inorganic dust such as silica, and its health effects, has not been studied yet, but there are numerous studies [6] of silica-related occupational hazards, such as lung cancer in various occupations, like those involved in the ceramic industry, mining, and related milling operations. The exposure levels of RCS in the longeing arena in our current study are 0.020-0.086 mg/m³. This is lower than the exposure seen in high-risk occupations, but the excess lifetime risk of lung cancer was still estimated as 0.055-0.068% in our subject. Furthermore, even though the exposure level of horse trainer is lower than other classical silica exposed occupations, some articles suggest that relatively low dose exposure occupations also have high risk of lung cancer [7]. For example, Steenland and Sanderson [7] reported an article about the standardized mortality ratio of lung cancer in 4,626 crystalline silica exposure workers, the sand workers. The estimated average exposure was 0.05 mg/m³ in 9 years of average employment length. There were 109 deaths of lung cancer, and the standardized mortality ratio of lung cancer was 1.60 (95% confidence interval, 1.31 to 1.93) in all sand workers, including the workers engaged in crushing, wet process, milling and administration. Furthermore, the relatively low cumulative exposure level (below 0.10 mg/m³-years) also has a high mortality ratio, in exposure-response analyses of that article.

From that point of view, we think that the exposure level of the horse trainer was enough to have caused the lung cancer, because the horse trainer was exposed to 0.020-0.086 mg/m³ crystalline silica for 23 years. Robustly, the cumulative exposure of the horse trainer could be calculated by multiplying 0.020-0.086 mg/m³ and 23 years (0.46-1.98 mg/m³-years). If we take the lag time to be 15 years, the exposure years are 8 years, and the cumulative exposure level is 0.16-0.69 mg/m³-years. The calculated cumulative exposures of horse trainers are greater than those of other sand workers [7]. Therefore, we would like to once again suggest that the exposure level of horse trainer is high enough to have epidemiological ramifications for the occupational risk of lung cancer.

We face several limitations in this article. We cannot compare the seasonal variation of RCS exposure level. Therefore our results of the RCS level lack generalization to other environmental settings. The 8-hour TWA of total dust and RCS during longeing were conservatively calculated with the assumption that the exposure during all other working hours, including canter-play, is zero. Hence, the RCS level becomes higher when we consider other exposure that the worker had

suffered. For the TWA of RCS in the FKT data, we used the assumption that the proportion of RCS in the total dust is the same for the ORANGE data and the FKT data. Hence, if there are different proportions of crystalline silica in bulk samples between the ORANGE data and the FKT data, this assumption could bring error in exposure assessment.

Horse trainers traditionally are not aware of the risks of exposure to RCS, and do not generally use personal protective equipment in the longeing arena. Therefore, to prevent lung cancer in horse trainers, adequate management and further study of RCS exposure are needed.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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