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EC PULMONOLOGY AND RESPIRATORY MEDICINE

Mini Review

Occupational Lung Cancer: Occupational Carcinogens

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Received: November 20, 2018; **Published:** December 27, 2018

Abstract

Lung cancer is the leading cause among all cancer types in cancer mortality and incidence in the United States (U.S.), 2018. Occupational lung cancers are caused by various occupational exposures in the workplace. There are 20 occupational agents associated with lung cancer. The objective of this mini-review article is to highlight occupational agents that are recognized as primary causes of lung cancer based on the report that the International Agency for Research on Cancer (IARC) and other epidemiologic studies confirmed in the literature and also recommend preventive measures with the evidence-based intervention and policies to reduce lung cancer in the workplace.

Keywords: *Lung Cancer; Occupations; Carcinogens; Occupational Carcinogens; Exposures; Risk Factor; Prevention; Workplace; Mortality; Incidence*

Abbreviations

U.S.: United States; IARC: International Agency for Research on Cancer; BCME: Bis(chloromethyl) Either; CME: Chloromethyl Either; PAR: Population Attributable Risk

Introduction

Lung cancer death continues to be the leading cause among all cancer types in both males (83,500 estimated deaths) and females (70,500 deaths) in the U.S., 2018 [1]. Lung cancer incidence is the second leading cause of all new cancer cases in both males (121,680 estimated incidence) and females (112, 350 incidence) in 2018. The lung cancer five-year survival rate (18.6%) is lower than many other leading cancer sites, such as colorectal (64.5%), breast (89.6%) and prostate (98.2%). The five-year survival rate for lung cancer is 56% for cases detected when the disease is still localized (within the lungs). However, only 16% of lung cancer cases are diagnosed at an early stage. For distant tumors (spread to other organs) the five-year survival rate is only 5%. More than half of people with lung cancer die within one year of being diagnosed. The main risk factor for lung cancer is cigarette smoking which is accounted for 85% of lung cancer (90% in males; 79% in females) [2] and other risk factors include occupational factors, air pollutions, and radiation [3].

Reported and confirmed occupational carcinogens for lung cancer

Occupational lung cancer is clearly caused by occupational carcinogens in the workplace. There are a variety of occupational risk factors associated with lung cancer [4,5], including 10 carcinogens (asbestos, aflatoxin, arsenic, bis(chloromethyl) either, chromium, coal tar, mustard gas, nickel, radon, and soot) which the IARC evaluated to have sufficient evidence for carcinogenicity to humans as categorized as occupational lung carcinogens in Group1 based on epidemiologic studies [4]. Epidemiologic studies on other occupational exposures have reported significantly elevated risk of lung cancer. Chemical workers exposed to acrylonitrile have been reported an excess risk of lung cancer [6,7]. An epidemiologic study of vinyl chloride industry has reported an increased risk of lung cancer [8]. Several studies in the U.S. and Europe have reported increased risk of lung cancer among welders in shipyards [9]. Several surveys of workers exposed to chlorinated toluene have found about 3-fold increased risk of lung cancer, but the results were based on small numbers [10,11]. Isopropyl alcohol was associated to lung cancer in a small group of the U.S. chemical factory workers [12]. A 2-fold increase in lung cancer was reported among workers exposed to inorganic mercury [13,14]. Carpenters exposed to wood dusts have been reported to be at increased risk of lung cancer in an epidemiologic study [15]. Paper and pulp workers have been reported at increased risk of lung cancer [16]. Lung cancer risks have also been reported to occur excessively among cooks and bakers [17,18]. Lung cancer risk was increased in hazardous occupations including iron mining, smelting, painting, coal gasification, aluminum and coal production [19].

It has been estimated that 6 - 10% of all cancers can be attributable to occupational exposures [20]. This would represent a range of 14,042 - 23,403 all new lung cancer cases and 9,243 - 15,405 all lung cancer deaths due to occupational exposures in the U.S., 2018.

Occupational risks of lung cancer are quantitatively estimated by calculating the population attributable risk (PAR). The PAR measures the burden of disease attributed to given risk factors [21]. There were 102,000 deaths from occupational lung cancer worldwide, using a mean PAR of 9% [22].

Occupational carcinogens for lung cancer reported by the IARC are briefly summarized below because these agents have been confirmed as sufficient evidence for carcinogenicity to develop lung cancer based on epidemiological studies and animal experiments as well.

Asbestos

There is sufficient epidemiologic evidence for carcinogenicity of asbestos associated with lung cancer. Asbestos-induced lung cancer is generally characterized by a latent period of 15 - 20 years or longer between start of exposure and onset of the disease. In a mortality follow-up of 17,800 U.S. and Canadian asbestos insulation workers, there was a 2-fold increase of lung cancer during the period 10 - 14 years after initial employment [23]. Asbestos is used in roofing products, fraction products, asbestos cement, insulation, and break [3,5,24]. Occupations with occupational exposures to asbestos include insulation workers, break and shoe workers, shipyard workers, sheet-metal workers, plumbers and pipe-fitters [5]. The major industrial use of asbestos is restricted to chrysotile in the manufacturing of piping, roofing, insulation, and friction materials [5]. A characteristic of asbestos-related lung cancer is its synergistic relationship with cigarette smoking. In a combined analysis of 6 occupational groups, increased risks were found among asbestos-exposed workers who did not smoke, while among smokers, asbestos was shown to interact with smoking in a more than additive, and probably multiplicative effect [25,26].

Bis (Chloromethyl) Either (BCME)

In the late 1960s, a high risk of lung cancer was reported among American, Japanese, German, and French chemical workers exposed to BCME during the manufacturing of ion exchange resins [27-29]. Dose-response relationships were evident with a high proportion of lung cancer in young men and nonsmokers [30,31]. Risk decreased due to reduction of exposure, suggesting that the chemical may affect later as well as during early stage of lung carcinogenesis.

Chromium

An elevated risk of lung cancer in the U.S. chromium production industry was reported in 1949 [32]. Since this report, several other studies have reported elevated risk of lung cancer among chromium workers, pigment industry workers, chromium plasters, and workers producing ferrochromium alloys in the U.S., Great Britain, Japan, German, and Italy [9,33,34].

Nickel compounds

An epidemiologic study demonstrated an excess risk of lung cancer among workers in nickel refinery in South Wales in 1958. Studies of nickel refinery workers in Norway and Canada confirmed that the risk of lung cancer was confined during the early stage of refining involving heavy exposure to dust from relatively crude ore [9]. In 10 cohort studies, it was concluded that nickel compounds may contribute to occupational lung cancer because of elevated risk of lung cancer among nickel refinery workers [35].

Polycyclic hydrocarbons

Elevated risk of lung cancer has been reported in several occupational groups heavily exposed to polycyclic aromatic hydrocarbons in the U.S., Canada, and Great Britain [36]. In the U.S., a study on mortality experience of 58,828 steelworkers found that men in the coke plant had an excess risk of lung cancer 2.5 times than other steelworkers [37]. The excess risk of lung cancer among steel foundry workers was less reported in North America and Europe [36]. Cohort studies of nearly 100,000 railroad workers in the U.S. and Canada reported a 40% higher risk of lung cancer among workers with the longest duration in job experience and exposure to diesel [38,39].

Radon

Increased risks of lung cancer have been observed among underground miners in North America, Europe, and Asia because miners inhale radon daughter products [40]. An excess risk of lung cancer has been described among phosphate workers, whose exposure levels to radon appear to be lower among underground miners [41]. A recent study to examine the risk of lung cancer by histological subtypes associated with exposure to radon among the Ontario uranium miner's cohort showed that small cell lung carcinoma had the strongest association with cumulative radon exposure [42]. Epidemiologic studies on radon exposure with cigarette smoking have reported an excess risk of lung cancer in a more than additive and nearly multiplicative effect [43].

Silica

Exposures to crystalline silica was confirmed to induce lung cancer in one experimental animal study [44]. In a study in Montreal, silica was associated with significantly increased risk of lung cancer [45]. Pottery workers exposed to silica has been reported to experience an increased risk of lung cancer [46]. In a nested case-control study of lung cancer among a large cohort of silica-exposed miners and pottery workers in China, only a small increase in smoking-adjusted risk of lung cancer was detected among these workers [47]. Most study results reviewed in this article did not reported if risk of lung cancer was adjusted for cigarette smoking. Significance of the exposure to occupational carcinogens varies according to smoking status. A multicenter case-control study conducted in Europe concluded that the odds ratio for lung cancer in smoking females was 1.75, although no increased risk was detected for males [48]. Another cohort study has detected excess risk of lung cancer in nonsmoking females who worked as painters, wood and paper workers [49].

The cited occupational risk factors reviewed in this article confirmed that lung cancer was clearly caused by these known risk factors in the work environment. This is significant scientific evidence to determine a clear causal relationship between occupational exposures and lung cancer etiology for more policies to strengthen evidence based preventive measures and lung cancer surveillance in workplaces since toxic levels of occupational exposures still exist. This is an important implication to implement proper protocols in place to reduce incidence and mortality of occupational lung cancer.

Recommendation

I recommend three important practical strategies for prevention and control of occupational lung cancer. First, pulmonologists should take information on history of occupational exposures from patients in detailing the job history. All routine occupational history records taking should include the initial and present occupations, previous occupations, and specific types of exposure recognized as posing the greatest occupational risk for lung cancer, such as fumes, gases, dust, and other chemicals. Second, implementation of an evidence-based occupational safety and health modeling as hierarchy of control is vital to program success as engineering control is the top priority for occupational safety and health agendas to reduce environmental exposures and hazards supported by safety policies and regulations. Engineering control can address solutions to reduce hazards in the current work environment because the safety equipment or machinery is not effective for worker protection or the chemicals used in the workplace are not properly contained or stored. So, safety engineers are important to redesign equipment or machinery function for better protection and hazard containment in addition to prioritizing importance of screening and early detection programs especially for occupations with more late stage cancer clustered data. Third, well-designed epidemiologic studies are needed to identify more occupational carcinogens associated with lung cancer to make further recommendations and minimizing of not eliminating hazard exposure levels in the workplace.

Conclusion

In conclusion, occupational lung cancer is clearly caused by prolonged exposure to chemicals and materials in the work environment. Occupational lung cancer is preventable through health promotion, awareness, and preventive measures in the workplace. In order to reduce incidence and mortality of occupational lung cancer, prevention and intervention in the workplace are needed and must include (1) primary prevention programs to avoid potential exposure and use proper safety education to the workers; (2) secondary prevention program that emphasize to increase medical screening practices; and (3) appropriate surveillance programs. Ultimate prevention of occupational lung cancer could be effectively accomplished when health administrators, epidemiologists, industrial hygienists, occupational physicians, and safety engineers work closely as a team to provide proper guidelines for prevention strategies and control.

Acknowledgements

The author would like to thank Dr. David Bang, U. S. Centers for Disease Control and Prevention, Division of Cancer Prevention and Control for his helpful scientific comments and editorial suggestions.

Conflict of Interest

No conflict of interest to be declared.

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Volume 8 Issue 1 January 2019