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Review article

Cobalt related interstitial lung disease

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ABSTRACT

Cobalt exposure in the hard metal and bonded diamond tool industry is a well-established cause of ILD. The primary theories regarding the underlying mechanism of cobalt related ILD include an immunologic mechanism and an oxidant injury mechanism. Cobalt related ILD may present in subacute and chronic forms and often has associated upper respiratory symptoms. The evaluation begins with a thorough occupational history and includes PFTs, HRCT, and bronchoalveolar lavage. HRCT findings are nonspecific and may resemble NSIP, UIP, sarcoidosis, or HP. The finding of cannibalistic multinucleated giant cells is diagnostic provided there is a history of exposure and appropriate changes on imaging; however, when these cells are not found on lavage, lung biopsy is required for diagnosis. Giant cell interstitial pneumonia is the classic pathologic pattern, but cobalt related ILD may also present with pathologic findings of UIP, DIP, or HP. When cobalt related ILD is suspected, removal from exposure is the most important step in treatment. Case reports suggest that treatment with steroids results in symptomatic, physiologic, and radiographic improvement.

Contents

1. Introduction

Cobalt is a metal with a variety of industrial uses including the manufacturing of hard metals. Cobalt exposure can cause both

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occupational asthma and interstitial lung disease (ILD) [1]. However, development of cobalt-related ILD has only been reported in workers in the hard metal and diamond bonded tool industries.

Pulmonary symptoms and infiltrates on chest radiographs were first noted in hard metal workers in Germany in the 1940s [2]. Giant cell interstitial pneumonia (GIP), the most common pathology associated with cobalt related ILD, was first described by Liebow in 1968 but was thought at the time to be idiopathic [3]. Abraham and Spragg first described the association of hard metal exposure and GIP in 1979 in a patient working in the hard metal tool industry [4]. This was followed by a case series of GIP diagnoses in diamond polishers in 1984 by Demedts [5]. As hard metal consists of both tungsten and cobalt, it was initially unclear which metal caused ILD. Subsequent animal models and case reports of cobalt related ILD occurring in bonded diamond tool manufacturing in the absence of tungsten demonstrated that cobalt was the causative agent [1,5,6]. Due to the evolving understanding of cobalt related ILD over the last several decades, this condition is referred to in the medical literature by various names including Cobalt lung, Giant Cell Interstitial Pneumonitis (GIP), hard metal pneumoconiosis and hard metal lung disease [6]. In this review, we will refer to the condition as cobalt related ILD.

Diagnosing cobalt related ILD is important for several reasons. First, the prognosis of cobalt related ILD is different from that of the idiopathic interstitial pneumonias (IIPs) [7]. Additionally, this diagnosis has implications for treatment and prevention, including elimination of ongoing cobalt exposure for the affected worker and primary and secondary disease prevention efforts among exposed co-workers [8,9]. In this review, we will highlight occupational exposures to cobalt, clinical features that should increase suspicion for this condition, and diagnostic workup and management.

2. Use of cobalt in manufacturing

Cobalt has several industrial uses, but not all have been shown to cause ILD (Table 1) [10]. Cobalt related ILD only occurs when workers are exposed to cobalt through the manufacturing or use of tools created by the process of powder metallurgy, or the formation of materials from metal powders. Powder metallurgy occurs in the hard metal industry in which tungsten carbide and cobalt are combined to form a metal matrix and in the bonded diamond tool industry in which cobalt powder is used as a matrix for diamonds [5,6,10,11].

Hard metal is a substance created by mixing and heating tungsten carbide and cobalt along with small amounts of other metals. The resultant matrix is called a hard metal because it is 90–95% as strong as diamond, which makes it ideal for use in tools designed to machine, grind, or cut metals and in drilling technology (Table 1) [10,12].

The production of hard metal begins with mixing powdered tungsten and carbon black. Workers then heat the mixture and blend it with cobalt and, in some cases, small amounts of other carbides and metals such as nickel, chromium, tantalum, titanium, or niobium. The metal matrix is then compressed into the desired shape and heated. The final steps in production include grinding, polishing, and machining the hard metal; while all steps of manufacturing expose workers to hard metal dusts, these final steps likely result in the highest levels of exposure [10,13]. Exposure may also occur during the use of tools containing hard metal.

Although the term hard metal lung disease is often used to refer to cobalt related ILD, it is important to note that exposure to cobalt in the bonded diamond tool industry also causes disease [5,10,11,14]. In the manufacturing of bonded diamond tools, cobalt powder forms the matrix for microdiamonds, and the proportion of cobalt in these tools can be up to 90% by weight, which can lead to high levels of exposure among workers in this industry [10]. In addition, in the manufacturing of softer metals, a hard metal carbide coating can be applied to increase the durability of the surface of the softer metal, which may also lead to hard metal lung disease in exposed workers [15]. Some occupational exposures to cobalt, however, do not involve powder metallurgy and have not been linked to ILD. These exposures, including mining, chemical and medical uses, and the production of alloys, are described in Table 1 [10].

3. Pathogenesis

The pathogenesis of cobalt related ILD remains unclear. Parenchymal lung disease related to cobalt exposure was first reported in hard metal workers in Germany in the 1940s, and soon thereafter case reports emerged from the United States and other European countries [2,12]. At that time, it was unclear whether cobalt or tungsten was the primary cause of hard metal lung disease, but it is now evident based on animal models and case series that cobalt is the causative component of parenchymal disease related to hard metal [6,16,17]. Animal models in the 1950s showed that cobalt, rather than tungsten, exhibited significant acute pulmonary toxicity when injected intratracheally or inhaled [18–20]. This data

Table 1
Occupational exposures to cobalt.

Exposures known to cause cobalt related interstitial lung disease	
Hard metals	Manufacturing
	Surface coating
	Tool maintenance and sharpening
Bonded diamond tooling	Manufacturing
	Tool maintenance and sharpening
	Tool use
Exposures not known to cause cobalt related parenchymal disease	
Cobalt mining	Mining
	Refining
Alloys	Superalloy manufacturing
	Magnet alloys
Medical uses	Prosthetic joints
	Veterinary uses
Chemical uses	Catalysts in the petrochemical and plastic industries
	Colors for glass and ceramics
	Adhesives
	Batteries
	Recording tapes

Data from Ref. [10].