

Metalworking Fluid Exposure in the Automobile Industry: A Case-Control Study of Esophageal Cancer Mortality

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ABSTRACT

Results are reported from a nested case-control study of 60 esophageal cancer deaths among 46,384 hourly employees who worked in automobile manufacturing. Workers were exposed to metalworking fluids (MWF) in machining and grinding operations.

Using incidence-density sampling, controls were selected with a sampling ratio of 20:1 from among co-workers who remained at risk at the age of death of the case, matched on year of birth, race, gender, and plant. Conditional logistic regression was used to evaluate the risk associated with cumulative exposure to each of three types of MWF (straight, soluble, and synthetic MWF), as well as with years of exposure to selected components and additives, including nitrosamines, sulfur, biocides, and several metals.

Esophageal cancer was found to be significantly associated with exposure to both soluble and synthetic MWF in grinding operations. These associations were observed for both cumulative exposure and duration of

exposure, although linear trends were present only for duration. Working with soluble MWF in grinding operations for more than 12 years was associated with a 9.3-fold risk of esophageal cancer mortality (95% CI: 2.1-42.1). When cumulative exposure rather than duration was considered, the odds ratio (OR) was elevated at 2.5 or greater in all exposure categories; in the middle category of cumulative exposure the OR rose to 5.9 (95% CI: 1.9-18.8). The OR for ever grinding with synthetics was 4.1 (95% CI: 1.1-15.0). Elevated risk was also identified in association with two agents commonly present in both synthetic and soluble fluids, nitrosamines and biocides. For any exposure to nitrosamines, the OR was 5.4 (95% CI: 1.5-19.9); for biocides the OR was 3.8 (95% CI: 0.8-18.9). However, since the same workers were exposed to grinding with synthetics, nitrosamines, and biocides, it was not possible to separate out the specific risks associated with these components.

Assessment of the Potential Toxicity of Metal Removal Fluid Additives

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ABSTRACT

Exposures to water-based metal removal fluid (MRF) aerosols have been associated with a wide range of acute respiratory effects that include airway irritation, inflammation, and airway constriction. Although many of these effects are reversible and most likely manifestations of the normal defensive mechanisms of the lung, they can also be indicative of the early development of chronic inflammatory-related disorders such as airway hyperreactivity, pulmonary pneumonitis, and fibrosis. The continual introduction of new MRF additives to enhance performance and stability and to control bacterial and fungal contaminations continues to raise major concerns about the potential toxicity of these complex fluid mixtures. Recent investigations into the efficacy of adding high molecular weight polymer poly(ethylene oxide) (PEO) to MRFs to decrease misting have raised the question of whether or not PEOs can cause lung inflammatory reactions. Since high molecular weight PEOs decrease the ability to generate respirable aerosols, preliminary animal studies had to use the intratracheal instillation route of administration. Results demonstrated that instillation of as much as 1 milligram of the high molecular weight PEOs (median molecular weight of 1 million) in 200 μ l of isotonic saline were required to invoke a measurable inflammatory response in the lung, characterized by the accumulation of peripheral blood phagocytic neutrophils in the conductive and respiratory airways. Comparison of this response with the effects of a nanogram dose of the known pro-inflammatory agent lipopolysaccharide suggested that the PEO-induced response was relatively low, non-specific, and most likely representative of normal lung defense mechanisms observed on exposure of the lung to unreactive inhaled material. Since PEOs in a machining operation rapidly break down to lower molecular weight products, PEOs with a median molecular weight of 0.3 million were also examined, and found to demonstrate an enhanced response per unit weight. These latter results suggested that the number of polymer molecules instilled into the lung was proportional to the resulting biological response. Although these preliminary studies indicated a relatively low toxic potential of PEO, they did not indicate possible inflammatory effects and/or compromised host

defenses that might result from repeated low-level exposures to both high and low molecular weight PEOs when added to MRFs. The need to develop a cost-effective strategy to assess the toxic potential of water-based MRFs in the presence and absence of the many additives used to decrease exposures and manage microbial contaminations is indicated.

INTRODUCTION

The health risks associated with exposures to metal removal fluid (MRF) aerosols continue to be a major concern of the automotive industry. The increased use of soluble formulations has been associated with increased reports of acute respiratory effects that include nasal and airway irritation, increased phlegm production, coughing, airway constriction and reversible pulmonary function decrements.^(1,2) These acute biological responses are closely associated with inflammatory reactions that in some cases have been attributed to exposures to specific metal-removal fluid additives and/or contaminants. Epidemiological studies have also suggested links between MRF aerosol exposure and such inflammatory-related lung diseases as chronic airway hyperreactivity and asthma.⁽¹⁾ Current areas of investigation are focused on understanding the inflammatory toxicity of exposures not only to the metal removal fluid oil, but also to the additives used to manage and control microbial contamination, including alkanolamines, biocides, and microbial-derived endotoxins and molds.⁽³⁻⁶⁾ Recent interest has also included new additives designed to reduce aerosol generation in water-based metal removal fluid machining operations. Drs. Gulari, Smolinski, and Manke, in collaboration with the automotive industry, have recently demonstrated that a high molecular weight poly(ethylene oxide) (PEO)—median gram molecular weight (GMW) 1 million—containing trace amounts of fumed silica (Polyox[®], Union Carbide Corp.), when added to water-based metal removal fluids at concentrations as low as 0.015% (v/v), will dramatically reduce aerosol generation in a machining operation for up to 8 hours. As part of these ongoing investigations, concerns about the potential of different molecular weight Polyox[®] to cause airway inflammation have been raised by potential end-users.

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II

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The reader will notice a variety of nomenclature differences among authors when referring to these fluids which were the subject of the Symposium and of this volume. Indeed, even the Symposium title reflected some of this variation: "*Metalworking Fluids Symposium II*," and "*The Industrial Metalworking Environment: Assessment and Control of Metal Removal Fluids*." Lest we add to the confusion, our use of the term *metalworking* in the title "*Metalworking Fluids Symposium II*" was a conscious decision based on nothing more than to maintain continuity with the title from the first Symposium. It was for that reason that "*Assessment and Control of Metal Removal Fluids*" was added in recognition of, and to call attention to the fact that the vast majority of research and data to date has been generated on a subset or class of metalworking fluids known as **metal removal fluids**. In addition to metal removal fluids, the very general term 'metalworking' fluids also encompasses the large and general classes of *metal protecting* fluids, *metal forming* fluids, and *metal treating* fluids. Besides functional differences between metalworking fluid classes, there are substantial compositional differences both between and within classes. So while it is somewhat sloppy though quite common and generally harmless to use generic terms such as metalworking fluids, or machining fluids, or coolants, the reader should be well aware of these important distinctions and that in virtually all instances where there is a connection with purported health effects, the person is really referring to that subclass of metalworking fluids known as *metal removal fluids*.

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