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Brief Communication

Occupational Asthma in a Home Pieceworker

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ABSTRACT. A 67-yr-old woman presented to a free-standing medical center with respiratory distress of 1 day's duration. She was found on evaluation to have asthma associated with "dipping" the ends of polyurethane-coated wire into molten solder in the production, in her home, of components for the electronics industry. This process has been known to result in the evolution of isocyanates. The patient's sister had also developed cough and wheeze after she performed similar home piecework. Neither the manufacturer nor the distributors of the wire had provided a warning of its potential respiratory hazards. This episode emphasizes the importance of the occupational history, and of following-back thoroughly on cases of occupational disease. In addition, this episode reminds us that home pieceworkers are unlikely to have benefit of advice from industrial hygienists or others skilled in recognizing potentially hazardous situations.

FREQUENTLY clinicians fail to consider disease entities of occupational or environmental origin in forming their differential diagnoses.[1] It has been suggested that widespread neglect of the occupational history forms the basis for this oversight.[2] This neglect, in turn, is arguably a consequence of failure to emphasize the importance of the occupational history in literature on physical diagnosis and family medicine,[3] and also of inadequate undergraduate training in occupational medicine.[4]

The "sentinel health event" (SHE) concept offers an approach to improved clinical recognition of occupational disease.[5] A sentinel health event (occupational) is defined as "an unnecessary disease, disability, or untimely death which is occupationally related and whose occurrence may: (1) provide the impetus for epidemiologic or industrial hygiene studies; or (2) serve as a warning signal that materials substitution, engineering controls, personal protection, or medical care may be

required."[5] Concise tables have been developed which list those sentinel diseases for which there exists a high likelihood of occupational origin.

We describe herein a case of severe asthma which occurred in a retired woman. The examining physician learned in the course of obtaining an occupational history, that while doing electronics piecework in her home, the woman had been exposed to fumes from polyurethane-coated wire. On the basis of that history, he suspected a diagnosis of occupational asthma and requested consultation from an occupational physician. This case illustrates the value of the sentinel health event concept as guide to the diagnosis. Moreover, it demonstrates the dangers which may confront workers in "cottage industries" who are frequently uninformed as to the hazards of the materials with which they work.

Case report

In March 1984, a 67-yr-old white female presented to an emergency center with symptoms of severe shortness of breath, cough, and a feeling of "choking to death" of 1 day's duration.

The patient was in her usual state of health, with occasional cough and shortness of breath on exertion, until 9 days prior to admission, when she first engaged in "dipping" polyurethane-coated wire into solder. This process is known to result in the evolution of isocyanates.[6,7] At the end of a 2-hr period in which she dipped three bundles of wire (225 wire segments), she developed cough and felt some heaviness in her chest but these symptoms resolved gradually over the ensuing week.

On the day prior to admission, the patient dipped wire for the second time. After 1 hr of work, in which she finished one bundle of wire, she felt extremely fatigued and was unable to proceed further. She could not catch her breath, she began to cough and later to wheeze, but she felt no chest pain. Through the night, she continued to experience cough, productive of phlegm without hemoptysis. She reported feeling hot and chilly, but denied muscle aches or joint pain. On the day of admission, her shortness of breath, cough, and wheezing worsened. She denied taking any medication, had no known allergies, had smoked two packs of cigarettes per day for 30 yr and had been told that she had "emphysema." She had never previously experienced episodes of wheezing asthma or symptoms similar to those leading to admission.

On physical examination, pulse was 122/min; respirations 40/min; and blood pressure, 150/90 mm Hg. She was afebrile. Diffuse expiratory rhonchi were present. The chest radiograph showed evidence of emphysema. Electrocardiogram showed sinus tachycardia with left axis deviation and nonspecific ST-T wave abnormalities. Arterial blood gases performed approximately 3 hr after the initiation of oxygen therapy when symptoms had partially abated were: pH, 7.40; pCO_2, 30.9 mm Hg; pO_2, 96.9 mm Hg; HCO_3, 18.9 meg/L; and O_2 saturation, 97.3%. The white blood count was 9.6 thousand with a normal differential. The patient was treated with intravenous aminophylline, aerosolized metaproterenol sulfate, and steroids. Her bronchospasm abated promptly. Pulmonary function studies performed when the patient was free of bronchospasm prior to discharge demonstrated a forced vital capacity (FVC) of 1.98 L (68% of predicted), forced expiratory volume in 1 second ($FEV_{1.0}$) of 1.5 L (72% of predicted), and a $FEV_{1.0}$/FVC ratio of 76%. She was discharged on the third hospital day on rapidly tapering prednisone and oral albuterol (Ventolin®).

Occupational history

The patient had worked for approximately 10 yr beginning at age 15 as a packer in a match factory. She described conditions there as very dusty, but she had experienced no respiratory symptoms. For another 10 yr (during the 1950s), she soldered unpainted metal lugs in the manufacture of electrical harnesses for airplanes. This work also caused her no respiratory distress. In the early 1960s, she worked for several years as a solderer making battery chargers; again she experienced no health problems. In the late 1960s, she worked as a sales clerk. She had not worked outside her home during the 10 yr before admission.

At the time of admission, the patient was retired and lived in a trailer home. In the wire-dipping operation, which she performed in her kitchen, she heated blocks of lead:tin solder in a soldering pot to a temperature of 650-700°F. When the solder was molten, she dipped each end of a 25-cm section of polyurethane-coated wire into the solder. This operation caused the plastic coating to vaporize, and the end of the wire to become coated with a thin layer of solder metal. The patient stated that on both occasions when she had performed the dipping, the stove fan in her trailer had been operating and the windows had been open. No flux was involved. The work was performed on a piecework basis under contract from a local electronics firm. The coated wires were used to manufacture electrical components of hospital beds and also to make portable radar detectors.

Other exposed individuals

A sister of the patient had performed the same wire-dipping operation in her home twice a week for 1 mo 3 yr previously. Although she had initially experienced no respiratory distress, she reported that she had gradually developed cough and wheeze and that she had one episode of severe dyspnea. She eventually ceased dipping because of her breathing problems, but continued to perform other home piecework. Two other relatives, a grandson and a nephew, also performed wire dipping in their homes. These two persons were not interviewed, but reportedly have not had symptoms related to dipping; nor have young children who lived in the home of the nephew.

Wire for the dipping operation was supplied to the patient, to her sister, and to the other family members by the patient's brother-in-law, who operated a small job shop which produced electronics items under contract for local manufacturers. The brother-in-law stated that he was not aware of the potential hazards involved in dipping, and that he had provided no information to his

family members concerning the potential toxicity of the materials. The patient's sister supplied samples of the wire to the investigators. The wire that was used in the dipping is 20-gauge copper, coated with nylon and overcoated with polyurethane. We learned that the distributor in Dayton, Ohio, obtained the wire from a company in Richmond, Indiana, which in turn, had obtained it from a manufacturer in Fort Wayne, Indiana. A material safety data sheet (MSDS) for the wire provided to customers by the manufacturer indicated that "decomposition products when heated unknown-may contain isocyanates." We learned subsequently, from the Executive Director for Development and Technical Operations of the wire manufacturing company, that this version of the MSDS had not been prepared until after our inquiry. Previous versions had apparently indicated only that the wire should be used "with adequate ventilation" and health hazards were listed as "unknown"; isocyanates had not been mentioned. The Executive Director stated further that a MSDS is not routinely furnished to customers for the wire.

The patient's family refused a request to perform environmental (air) sampling during subsequent dipping operations.

Discussion

The major point of this report is to illustrate the importance of the occupational history as a means of obtaining clues to a correct diagnosis. Asthma in an adult exposed to fumes of polyurethane plastic is an example of a sentinel health event.[5] The examining physician's recognition of the temporal association between the patient's exposure and her disease made possible not only a proper diagnosis, but also resulted in prevention of further exposure of the patient. Additionally, the follow-back investigation to the manufacturer and the subsequent correction of the inadequacies in the MSDS may have prevented similar exposures of other workers.

Although it was not possible to reproduce the workplace (home) situation to document the exposures to the patient during the dipping process, isocyanates would appear to be the most likely agent. This case is a reminder of a potentially important source of exposure to isocyanates. Isocyanates are highly reactive chemicals which are used widely in the manufacture of polyurethane plastics. Adverse effects of isocyanates on the respiratory tract include direct irritation, sensitization (including asthma), and chronic lung disease.[8,9] The possibility for release of isocyanate (toluene diisocyanate or TDI) on heating of polyurethane in solder has been described previously.[6,7] Paisley reported an outbreak of breathlessness and cough among wire dippers working in a factory manufacturing electrical goods. In that factory, solder in pots was maintained at 360°C (680°F) with local exhaust ventilation. Prior to the outbreak, a new wire, polyurethane-coated, had been introduced. Subsequent testing found that thermal decomposition of the polyurethane coating produced isocyanates and oxides of nitrogen. Similarly Pepys and et al.[7] described two patients who encountered TDI in fumes from soldering polyurethane-coated wire. They commented on the possibility of sensitization to TDI under conditions of limited exposure.

The mechanisms by which isocyanates induce lung disease have been reviewed recently.[10,11] Irritation is one of these mechanisms. It is likely that the asthmatic episode which developed in the index case in this episode involved an irritant reaction complicating preexisting chronic obstructive lung disease. Sensitization (immunologic or nonimmunologic) constitues a second possible, but less likely etiologic mechanism in the index case. This mechanism is less likely since the interval of 8 days between the initial "dipping" and onset of asthma is probably at the lower limit for the induction of sensitization.[12] Therefore, it is likely that the patient's serious bronchospastic reaction after her second exposure was also caused by the irritant effect of isocyanates. On the other hand, the pattern of gradually developing illness reported by the sister of the index case is more compatible with sensitization.

Regardless of causative agent, or the pathophysiological mechanism, this case illustrates the hazards of piecework in the home or "cottage industry." There are no estimates for the prevalence of this activity in the electronics or other industries. The Fair Labor Standards Act of 1938 protects workers in parts of the apparel and jewelry industry from home piecework. The goal of this law was limitation of the "sweat shop." The regulations established pursuant to the Act do not extend to the electronics industry. Home pieceworkers, and even their family members, may be exposed to hazardous chemicals in a setting where there may be poor ventilation and where other engineering controls, relatively common in the factory situation, are nonexistent. In addition, such workers have little or no access to safety information and no benefit of industrial hygiene consultation. Additionally, there are economic and social pressures on such workers not to admit employment, and therefore it may be exceptionally difficult for their physician to make the connection between illness and a toxic/occupational exposure.

A final point, which was illustrated by our follow-back investigation, concerns the lack of hazard information. Although we were able to trace the wire from the manufacturer through two intermediate distributors to a small shop and thence to family members, at none of these four interaction steps did there appear to be communication about the potential hazards of the materials being supplied. These are obvious errors, violating the right of workers to obtain information about the hazards of the materials with which they work.

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