Fever induced by fluorine-containing lubricant on stainless steel tubes

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ABSTRACT Three subjects, all smokers, handling stainless steel tubes suffered repeated attacks of general malaise, chills, and fever lasting for several hours, mainly after gas soldering. Provocations by rubbing smoking tobacco against a tube produced similar attacks, and leucocytosis, after a few hours. The presence of fluorine on the tubes and in the febrifacient tobacco was shown. A fluorocarbon polymer lubricant was suspected of causing the attacks. Heating (1000°C) of the tubes eliminated the effect.

Occupational chills and fever can result from various agents, including fumes of different metals (zinc, copper, manganese, and cadmium), fumes containing thermal decomposition products of fluorocarbon polymers, and aerosols containing proteins of micro-biological origin. We report three cases of fever of occupational origin.

Case histories

In a factory manufacturing electrical equipment three men (aged 28-32 years) complained of strange, frequent attacks of fever. All three were smokers, but one had recently stopped. All three had previously been healthy; none had a history of atopy. Each attack started with a feeling of general malaise, headache, joint and muscle pains, abdominal discomfort, dry cough, chills, fulminant fever (maximum 40°C) with euphoria, and ceased with an abrupt disappearance of the symptoms and the return of body temperature to normal.

All three men had handled stainless tubes made in Switzerland. The tubes were fetched from a store, cut into lengths, gas-soldered (with a solder not containing cadmium), and mounted in various machines. The attacks of fever started in 1974, shortly after the arrival of a new shipment of tubes. Tubes received earlier and later from the same producer were not associated with illness.

The attacks occurred mainly after gas-soldering of the tubes. Smokers, but not non-smokers, however,

had attacks simply after handling the tubes—that is, without soldering. The three workers affected were the only ones who had handled and soldered tubes of the 1974 shipment. One of the men rolled his own cigarettes, and his girl friend had an attack a few hours after smoking one of them.

Provocations

Attacks were produced experimentally: 0.5 g of tobacco was rubbed against 0.5 m of a 1974 tube. One of us smoked the tobacco in a pipe. Three to four hours later his temperature rose and after another three hours reached a maximum of 38.7°C (fig). This was accompanied by a corresponding increase in the leucocyte count, which reached a maximum of $18.4 \times 10^9/l$. Of these, $15.3 \times 10^9/l$ were polynuclear. The lymphocyte count was unaffected. The symptoms were of the same type as those reported by the workers. Auscultation showed wheezing and soft rales over the basal parts of the lungs. Dynamic spirometry showed nothing remarkable. Complement factors (C₃, C₄, C_{1q}, C_{1s}, and C₁-esterase-inhibitor) as well as several serum and plasma coagulation and fibrinolytic factors were studied before exposure, during the attack, and 24 hours later. The complement system remained unchanged, but coagulation factor XII showed a moderate increase during the attack and factor VIII and fibrinogen a slight increase the day after, when the C-reactive protein in serum was also slightly increased.

Further similar experiments showed that heating the 1974 tubes to 1000°C eliminated their febrifacient

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Body temperature and white blood cell count before and after smoking treated tobacco.

effect. This effect was resistant to degreasing of the tubes in a hot trichloroethylene bath.

Analysis

The symptoms resembled those of metal and polymer fume fever. Attention was therefore focused on these possible causes. 0.5 g of tobacco was rubbed against 0.5 m of different tubes. The tobacco was wet-digested, and the solution was analysed by atomic absorption spectrophotometry (table 1). Rubbing increased the chromium and nickel content from the tubes received in 1974 as well as from those received later. As the latter tubes did not provoke fever, it seems reasonable to assume that chromium and nickel can be excluded as a cause of the disease. Other metals studied did not increase significantly.

To ascertain whether the reaction was of the polymer fume fever type, we measured fluorine on the surface of the tubes (table 2). Pieces of tubes were heated to 1000°C in an airstream, which was bubbled through an alkaline solution. With the aid of an ion-specific electrode the solution was analysed for fluorine ions. Untreated tubes from the 1974 shipment contained large amounts of fluorine, while heated 1974 tubes, later shipments, and tubes from other manufacturers contained much smaller amounts. Determination of the fluorine content of tobacco proved much higher (35 µg F/g) after the tobacco had been rubbed against the tube than it was before (1 µg F/g).

Discussion

The observations made in the investigation warrant the tentative conclusion that the attacks of fever may

Table 1 Metals in tobacco

Metal	Untreated (µg/g)	Rubbed against	
		1974 tube (µg/g)	Tube from later shipment (µg/g)
Chromium	1	14	34
Nickel	2	10	22
Copper	12	No increase	No increase
Zinc	30	"	"
Iron	270	"	"
Manganese	120	"	"
Cadmium	0.4	"	"
Lead	1	"	"
Cobalt	1	"	"

Table 2 Fluorine on tubes

	µg F/m
1974 tubes	1500-2000
1974 tubes after heating	60- 70
Tubes from later shipment	50- 120
Tubes from other manufacturer	50- 100

have been caused by thermal decomposition products of a fluorine-containing compound on the surface of the tubes. Such products may have entered the body by inhalation of the contaminated ambient air during soldering or by cigarettes or pipe tobacco handled by contaminated fingers and afterwards decomposed and volatilised by the glow when being smoked.¹

We suspect that the compound was a fluorocarbon polymer used as a drawing (lubricating) compound in the production of the tubes. Unfortunately, we could not check this possibility because the producer refused to co-operate and because the amounts of compounds were not large enough to be identified analytically.

Fever caused by fluorocarbon compounds on metal is probably not rare, and some cases have been observed elsewhere.²

It is remarkable that a dramatic fever reaction was provoked by less than 20 µg of fluorine (0.5 g of tobacco containing 35 µg F/g). This is less than reported in earlier studies of polymer fever.³

Measurements in one of the workers of static lung volumes and the pressure-volume diagram suggested a mild pulmonary fibrosis. Frequent attacks of fever may thus not be harmless. This is also supported by post-mortem findings in one case of polymer fever.⁴

Complement analyses were performed by Dr Ann-Britta Laurell and coagulation factors were assayed by Dr Ulla Hedner.

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