Cardiac arrhythmias during occupational exposure to fluorinated hydrocarbons

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Abstract

The effects of occupational exposure to chlorodifluoromethane (FC 22) and dichlorodifluoromethane (FC 12) on cardiac rhythm were examined. The subjects were six men who repaired refrigerators (age 31-56, mean 46 years) and a control group of six plumbers (age 29-54, mean 45 years). Ambulatory electrocardiograms (ECG) were recorded for 24 hours on the day of exposure and on a control day. The ECG tapes were automatically analysed with a Reynolds pathfinder 3 apparatus and all aberrant complexes recorded by the machine were checked. One person read all the tapes without knowing whether or not they were recorded during exposure. The number of ventricular ectopic beats were compared between the day of exposure and the control day and with the tape of the control. In addition, the number of ventricular ectopic beats during exposure was compared with the number occurring during the rest of the day. The concentrations of fluorocarbons were measured in four instances. High peak concentrations of fluorocarbons (1300-10 000 cm^3/m^3) were measured during refrigerator repair work. No clear connection between fluorocarbons and cardiac arrhythmia was found, although one subject had several ventricular ectopic beats which may have been connected with exposure.

Fluorinated hydrocarbons (fluorocarbons) in high concentrations (25 000-100 000 cm^3/m^3) have been found to cause cardiac arrhythmias including sinus bradycardia, sinus tachycardia, 1° AV blocks, and ventricular ectopic beats in animals.¹

Workers repairing refrigerators may be exposed to high peak concentrations of fluorocarbons. In an unpublished Swedish study of refrigerator repair work peak concentrations during some ten minutes

were 4430 cm^3/m^3 of a mixture of chlorodifluoromethane (FC 22) and chloropentafluoroethane (FC 115), 3500 cm^3/m^3 and 620 cm^3/m^3 of dichlorodifluoromethane (FC 12) and over 10 000 cm^3/m^3 of FC 22. There are few data on the effects of these concentrations on man and the aim of the present study was to examine whether exposure to FC 22 or FC 12 can cause cardiac arrhythmias in exposed workers.

Subjects

Originally 20 male repair workers and 20 male plumbers were selected into the study. During a one year follow up, only six repair workers (age 31-56, mean 46 years) performed large scale repair work of which the occupational health nurse was informed so that the recording device could be used. Six plumbers (age 29-54, mean 45 years) were selected as their controls.

All the subjects underwent a medical examination (including a medical history, a clinical examination, lung radiograph, and electrocardiography at rest) to exclude any cardiovascular diseases.

Methods

Ambulatory electrocardiograms (ECG) were taken for 24 hours on the day of exposure and on a control day (an ordinary working day without exposure to fluorocarbons). In one person (No 1) three control tapes were recorded.

Large scale repair work on refrigerators is unusual. When information about such work came one to two days beforehand, environmental measurements could be arranged and the occupational health nurse could place the ECG electrodes on the morning of the workday. The control tapes were recorded on incidental days during one year. Thus the time lag between the exposure and control tapes could be several months. For technical reasons, a control tape of one person (No 2) was recorded for only seven hours.

The subjects kept diaries about their daily activities, such as exposure to fluorocarbons, physical activity, traffic, meals, smoking, and drinking.

The ECG tapes were analysed automatically with a Reynolds pathfinder 3 apparatus. They were also

recorded on to paper at a speed of 6.3 mm/sec. Because of the great number of false positive findings, all aberrant complexes recorded by the machine were checked visually on the paper trace. One person read all the tapes without knowing whether or not they had been recorded during exposure or whether they came from the controls.

The number of ventricular ectopic beats (VEBs) on the day of exposure was compared with that on the control day and also with the tape of the control. Furthermore, the number of VEBs during exposure was compared with that occurring during the rest of the day.

During the entire working period, the concentrations of FC 22 were measured in three cases and of FC 12 in one. The concentrations in the workers' breathing zones were measured with a Miran 1 A infrared spectrophotometer and by means of adsorption samplers in 30–60 minute samples.

Results

The VEBs were somewhat more common in the refrigerator repair workers than in the plumbers but, except in two subjects, the number of VEBs was low (table 1).

Subject No 1 had frequent unifocal VEBs that often occurred as bigeminy or trigeminy. In November 1986 his control tape showed some VEBs which almost totally disappeared at night (figure). On the day of exposure in August 1987, the number of VEBs was high but this was also true in the morning before exposure. The peak number of VEBs (an average 21/min) occurred about two hours after exposure to

Table 1 Average number of ventricular ectopic beats (VEBs) an hour (a) in refrigerator repair workers during exposure and on a control day and (b) in the controls. (Range given in parentheses)

No of pair	VEBs/h		
	Refrigerator repair worker		Control subject
	Day of exposure	Control day	
1	964 (0–1236)	23 (0–123) 549 (38–938) 84 (1–167)*	3.4 (0–27)
2	10 (0–24)	16 (6–24)	0.3 (0–2)
3	0	0	0
4	1.4 (0–13)	0.2 (0–1)	0.3 (0–3)
5	0	2 (0–12)	0
6	0.04 (0–1)	0.2 (0–5)	0

*Three separate control days.

fluorocarbons. Another peak of VEBs was found on the way home by car. At night, the VEBs disappeared almost completely but rose the next morning before starting work.

In a clinical exercise test unifocal VEBs were found during exercise but they disappeared after the pulse level rose above 130/min. There was no indication of ischaemia and ultrasound examination gave normal results.

In April 1988 a new control tape was recorded after the subject had returned from a holiday abroad. He reported that he had consumed some alcohol on the day preceding the recording. On that tape several VEBs were found, this time also at night. In the last control tape during which the subject had, according to his diary, done physically heavy work and handled a vaporised glue, the number of VEBs was small.

Number of ventricular ectopic beats (VEBs) a minute in one person on day of exposure and on control days. 13 August 1987 was day of refrigerator repair work. Exposure period is marked with a segment of a line on time axis. Others are control days.

Table 2 Concentrations of fluorocarbons (FC) in the workplace air during refrigerator repair work. (Time (min) the concentration remains over 1000 cm³/m³ is given in parentheses)

Subject No	FC	Duration of exposure (min)	Average concentration (cm ³ /m ³)	Peak concentration (cm ³ /m ³)
1	FC 22	70	170	3200 (4) 1400 (2)
3	FC 22	103	710	10 000 (26)
4	FC 12	48	202	2800 (5) 1300 (3)
5	FC 22	150	815	5800 (35)

Subject No 2 had 11–26 VEBs an hour during exposure. They were equally frequent at other times of the day and also on the control day.

Of the others, only subject No 4 had more VEBs on the exposure day than on the control day. They were few in number and did not correlate with exposure.

High peak concentrations of fluorocarbons were measured during work (table 2). The largest average and peak concentrations occurred in subjects 3 and 5 who had no VEBs at all.

Discussion

No cardiac arrhythmias were found to be clearly connected with exposure. One subject had several VEBs and a connection with exposure cannot be totally excluded. The average level of exposure in his breathing zone was low (170 cm³/m³) but the peak concentration was high (3200 cm³/m³). The VEBs were somewhat more common in the refrigerator repair workers than in the plumbers. The number of VEBs was low, however, when compared with what is known of VEBs in the normal heart.²

High peak concentrations of fluorocarbons in refrigerator repair work were found to be consistent with unpublished Swedish studies. The average concentrations of fluorocarbons during work were 170–815 cm³/m³ and the peak concentrations 1300–10 000 cm³/m³. In most cases the peak concentration lasted only a few minutes but in two instances the concentrations remained over 1000 cm³/m³ for 30 minutes. In two cases the peak concentrations exceeded the Finnish hygienic standards for 15 minutes (1250 cm³/m³).

One subject had an unexplained tendency to VEBs. He had no cardiac disease. Physical strain at work did not explain the VEBs since they were not present on another working day with physical strain, and they disappeared in an exercise test. The greatest number of arrhythmias were found on the day of exposure, and the peak of VEBs occurred two hours after exposure. On the other hand, the VEBs were also present at other times and they also increased after using alcohol. Similar observations have been made on subjects exposed to a fire extinguishing agent (bromotrifluoromethane, Halon 1301).³ One person with Fallot's tetralogy had multiple VEBs during exposure (K Lehtomäki, personal communication). Possibly a heart with an arrhythmic ten-

dency is susceptible to different arrhythmogenic agents—for instance, to fluorocarbons and alcohol.

Based on animal experiments, the arrhythmias seem to require much higher concentrations (100 000–200 000 cm³/m³)¹ than those found in the present study. In one experiment exposure of a person to 10 000 cm³/m³ of FC 12 for 2.5 hours did not cause arrhythmias, as evidenced by an ambulatory ECG.⁴

The few studies on occupational exposure have given contradictory results. In two studies a tendency to cardiac arrhythmias has been reported in connection with exposure to fluorocarbons.^{5,6} In a questionnaire study 118 workers in a pathology department reported palpitations 3–6 times as often as the 85 radiology workers who served as referents.⁵ The FC 22 used in the preparation of frozen sections was thought to have caused the arrhythmias. The FC 22 concentration measured during the work (two minutes) was 300 cm³/m³. Ambulatory ECGs were studied and atrial ectopic beats, paroxysmal tachycardia, and VEBs were found. No control recordings were made. Campbell *et al* reported palpitations more often in 27 refrigerator repair workers (26%) than in 14 controls (0%).⁶ No differences were found between the groups as regards their ECGs at rest.

In the present study no clear connection was found between fluorocarbons and cardiac arrhythmia. Based on this and some earlier studies, there is slight evidence that a heart with an arrhythm tendency for any reason might be susceptible to the effects of fluorocarbons. Although the present hygienic standards, based on the most knowledge, seem to be safe, one cannot be absolutely sure that they can protect an already compromised heart.

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