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Death Associated with Fluorocarbon Inhalation: Report of a Case

Reports of deaths associated with inhalation of volatile fluorinated hydrocarbons increased dramatically in the late 1960's [*1*] and, subsequently, several reports have detailed the physiological effects, tissue concentrations, and excretion rates for two of these fluorocarbons: trichlorofluoromethane (F-12) and dichlorodifluoromethane (F-11).

The toxicity of these fluorocarbons has been documented in laboratory studies using mice [*2*], dogs [*3*], and monkeys [*4*]. The latter two reports indicate that cardiac arrhythmias are produced by prolonged inhalation of F-11 and F-12 under laboratory conditions controlled to prevent anoxia. However, there is considerable evidence to indicate that controlled and limited use of these fluorocarbons as propellants for drugs, hair spray, etc. is safe; that is, it results in no detectable harmful physiological changes in the exposed individual [*5–7*]. It has also been suggested that the arrhythmia observed in the initial laboratory studies was due to asphyxia [*8*].

The apparent discrepancies in the observed physiological effects resulting from inhalation of these fluorocarbons may be resolved by considering the magnitude of the absorbed dose. The blood levels of F-12 in monkeys showing effects were approximately 5 mg/100 ml [*4*], and in humans showing no ill effects the blood levels ranged from 0.002 to 0.08 mg/100 ml [*9*]. These differences are consistent with the observations by Jack [*10*] that in dogs, blood levels of 25 μg/ml (2.5 mg/100 ml) of F-11 are necessary for cardiac sensitization to adrenaline challenge, and by Clark and Tinston [*6*] that F-11 blood levels up to approximately 2 mg/100 ml did not produce sensitization.

Several reports have detailed the fate of inhaled fluorocarbons [*11–13*] and have indicated that (1) the clearance from blood follows a two-phase curve, with the second phase indicating a blood half-life of 4 min for F-11; (2) the whole body clearance follows a single-phase curve with an average half-life of 40 min; and (3) the length of time fluorocarbons are retained in particular tissues is porportional to the fat content of those tissues.

Based on all of this information, one may hypothesize that excessive and prolonged inhalation of fluorocarbons will lead to tissue accumulations which, after critical threshold levels are reached, will initiate certain adverse physiological processes (including cardiac arrhythmia). The triggering of these processes may depend on maintaining tissue levels at or above the critical levels for some time. In this report, levels of F-11 and

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F-12 have been found (in tissues taken at autopsy from an individual whose death is attributed to inhalation of these fluorocarbons) which are compatible with the critical levels of these fluorocarbons observed in laboratory studies [*2–4*].

Case Summary

The following is a summary of an account given by a companion of the decedent who was present during the fluorocarbon inhalation.

At approximately 12 noon on 10 March 1974, the subject and a male companion were observed in an alley sniffing the contents of a plastic bag. Both boys reported that the bag contained vapor from an aerosol can of cooking spray[2] and that they both felt "high". The boys returned home until 6 p.m., after which they purchased another can of cooking spray from a grocery and returned to the alley where the decedent again sprayed the material into a plastic bag and "sniffed" the contents of the bag; however, the companion said he felt "too sick" to participate. After "several" sniffs, the decedent began to "act weird" and the companion took the bag and spray can away. The decedent "passed out" and mouth-to-mouth resuscitation was attempted by the companion. An ambulance was called at approximately 7 p.m. and on arrival at the emergency room, resuscitation attempts failed. Death was pronounced at 8 p.m.

Pathology Summary

Autopsy was performed the following day at 9 a.m. (during the 13-h post-mortem interval the body was stored at 40°F). The tissue samples were collected and placed in 4-oz. screw-capped jars and stored at −20°C for four weeks prior to assay for fluorinated hydrocarbons.

A complete postmortem examination was conducted on a well-developed, moderately well-nourished, 13-year-old male, 62.5 in. in length. The positive findings were limited to the respiratory system. The lungs together weighed 765 g and in the right middle and both lower lobes was marked congestion with sectioned surfaces draining an abundant amount of frothy pink fluid.

Toxicology Method

Samples of chopped, frozen tissue were placed while still frozen into stoppered, tared, 20-ml vials and weighed. Two millilitres of cyclohexane were added through the vial stopper, while maintaining an airtight container. After the vials were kept at room temperature for one hour, 0.5 ml of "head space" was injected into a Perkin-Elmer 3920 gas chromatograph fitted with a molecular sieve 13A column (⅛-in. by 6-ft stainless steel) maintained at 120°C. The injector and detector were maintained at 130°C. The nitrogen carrier gas was flowing at 50 cc per min. Under these conditions the retention time of dichlorodifuoromethane was 2.7 min and that of trichloromonofluoromethane, 10.2 min.

Fluorinated hydrocarbon standards for the assay were prepared by blowing small amounts of the gases into tared, stoppered, 20-ml vials containing 2 ml cyclohexane. After the flasks were reweighed, they were swirled occasionally for one hour, and 0.5 ml of the head space was then injected into the chromatograph. The can of cooking spray used by the decedent was assayed for fluorinated hydrocarbons in a manner similar to the standards. All assays of tissue, standards, and cooking spray were repeated and

[2] The cooking spray in this case was PAM® (American Home Products, Crawford, N.J.).

the average values are reported as weight of fluorocarbon per wet weight of tissue. The amount of standard fluorocarbons (up to 150 mg per vial) was linearly related to the peak height as measured from the recorder trace.

Results and Discussion

The results of analyses of two fluorocarbons in various tissues taken from the subject at autopsy are shown in Table 1. Based on the ratio of the fluorocarbons in the

TABLE 1—*Fluorocarbon content of tissues.*

Tissue	Dichlorodi-fluoromethane, μg/g[a]	Trichloromono-fluoromethane, μg/g[a]
Lung	94	35
Heart	180	49
Liver	23	2.9
Fat (omentum)	13	1.7
Bile	13	3.3
Kidney	5.4	1.1
Brain	3.5	0.5
Striated Muscle (iliopsoas)	0.5	0.5
Blood (heart)	1.2	0.6
Cooking Spray, %	43	57

[a] Based on frozen wet weight of tissue.

analyzed cooling spray (F-11, 43% and F-12, 57%), the tissue ratio of fluorocarbons should be nearer unity or in favor of the higher boiling F-12 [*9,14*]. One possible explanation of this discrepancy relates to the ambient temperature at the time of the incident, that is, 10°C. Since the fluorocarbons were sprayed into a plastic bag before inhalation, it is likely that the higher boiling F-12 (boiling point, 23.8°C) would have a tendency to condense on the walls of the bag, leading to a fluorocarbon mixture available for inhalation which would contain relatively more F-11 (boiling point, −21.6°C).

A direct evaluation of the blood levels and their physiological effects may be difficult in this case, due to the delay between inhalation of fluorocarbons and death (approximately 1.5 h). During this time some of the fluorocarbons would have been lost from the tissues. From studies of the half-life of fluorocarbons in blood [*9,11,12*], it is likely that the whole body level would decrease to approximately 20% of its peak level within 100 min after inhalation and that the blood content would fall to about 1% of its peak value. This implies that the peak blood fluorocarbon level in this case could have been as high as 18 mg/100 ml. This would be sufficient to initiate the events leading to cardiac arrhythmia and death [*4,10*].

The relative amounts of F-11 in these tissues are comparable with those reported for an earlier case [*15*], except that less fluorocarbons were detected in lung tissue in this study. These low levels may be attributed to the lung ventilation which occurred during the time between inhalation and death (1.5 h). Since the half-life of alveolar F-11 and F-12 is reported to be approximately 30 s [*16*], one could predict a rapid clearance from lung tissue.

Summary

This case documents postmortem tissue concentrations of fluorocarbons in an individual whose inhalation of cooking spray vapors was well documented. The data presented here should contribute to the information base which will assist the pathologist in determining the cause of death in cases related to inhalation of these fluorocarbons.

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