J. Pharm. Pharmacol. 1984, 36: 578–581
Received January 11, 1984

Passive inhalation of cannabis smoke

B. LAW*, P. A. MASON, A. C. MOFFAT, L. J. KING† AND V. MARKS†

Central Research Establishment, Home Office Forensic Science Service, Aldermaston, Reading, Berks, RG7 4PN.
†Department of Biochemistry, University of Surrey, Guildford, Surrey GU2 5XH, UK

Six volunteers each smoked simultaneously, in a small unventilated room (volume 27 950 litre), a cannabis cigarette containing 17·1 mg Δ^9-tetrahydrocannabinol (THC). A further four subjects – passive inhalers – remained in the room during smoking and afterwards for a total of 3 h. Blood and urine samples were taken from all ten subjects and analysed by radioimmunoassay for THC metabolites. The blood samples from the passive subjects taken up to 3 h after the start of exposure to cannabis smoke showed a complete absence of cannabinoids. In contrast, their urine samples taken up to 6 h after exposure showed significant concentrations of cannabinoid metabolites ($\leq$6·8 ng ml^{-1}). These data, taken with the results of other workers, show passive inhalation of cannabis smoke to be possible. These results have important implications for forensic toxicologists who are frequently called upon to interpret cannabinoid levels in body fluids.

When cannabis or cannabis resin is smoked, significant proportions of the cannabinoid compounds (ca 25%) are lost to the atmosphere in the side-stream smoke and are therefore not inhaled (Truitt 1971). Fish & Wilson (1969) identified three cannabinoids, including Δ^9-tetrahydrocannabinol (THC), in airborne particulate matter (>0·1 μm) of side-stream smoke following smoking of cannabis cigarettes. These reports, taken together with others on absorption of nicotine by non-smokers in a tobacco smoke-containing environment (Horning et al 1973; Feyerabend et al 1982), have raised the possibility of absorption of significant quantities of cannabinoids by the passive inhalation of cannabis smoke. It has been suggested that non-smokers in the same room with people actively smoking cannabis could passively inhale cannabis material from the smoke and thus inadvertently achieve significant blood and/or urine cannabinoid concentrations. Although this argument has been successfully used as a form of defence in United Kingdom courts of law against charges involving cannabis abuse, there have been insufficient data for the assumption to be tested.

A previous report (Zeidenberg et al 1977), purporting to show high urine cannabinoid concentrations due to passive inhalation, has been given little credence and has received scant attention. However, more recent studies (Wethe et al 1982; Perez-Reyes et al 1983; Mason et al 1983) have clearly shown that passive inhalation of cannabis can occur, albeit under extreme conditions.

The development of a new, broadly specific and sensitive radioimmunoassay (RIA) for the detection of cannabinoids (Law et al 1984a) has facilitated further investigation of this problem.

* Correspondence.

MATERIALS AND METHODS

Materials

Glass fibre filters (GF/A) were obtained from Whatman, Maidstone, Kent, UK and absolute alcohol (ethanol) 99·9% from James Burroughs, London, UK. Cannabis containing 9·8% THC, approximately 0·7% cannabinol and 5·6% cannabidiol was obtained from the Laboratory of the Government Chemist, London, UK.

All other equipment and reagents were as previously decribed (Law et al 1984a).

The cannabis resin was cut into small pieces (8 mm^3), mixed with cigarette tobacco, and rolled into cigarettes, average weight 1·15 g. The cigarettes contained an average of 175 mg resin, equivalent to 17·1 mg THC.

Experimental protocol

The experimental room was a small office, volume 27 950 litres which contained 3 desks and a filing cabinet, with no ventilation. There was a single door which was opened and closed approximately 18 times during the experiment for access to the subjects.

The experiment began with the six volunteers each smoking a cannabis-containing cigarette and taking between 10 and 34 min to smoke as much of the cigarette as they wished, in their normal manner. As they finished they left the room. All the subjects habitually smoked tobacco; three claimed previous experience of cannabis use. The experiment was

approved by the Ethics Committee of the University of Surrey.

In the same room as the six smokers were four healthy male passive inhalers, who remained in the room for up to 3 h after smoking had started.

At 35 min and 75 min, a 30 litre sample of air in the room was passed through a glass fibre filter at a rate of 2 litre min^{-1} by means of a small suction pump.

Body fluid sampling

All 10 subjects provided control blood and urine samples before the experiment and each smoker when they had finished smoking provided blood samples at approximately 0, 30, 60, 120 and 240 min, and urine samples at approximately 1, 2, 6 and 8 h.

The passive subjects provided blood samples at 1, 2 and 3 h, and urine samples at 1, 2, 3 and 6 h after the start of the experiment.

Blood samples (10 ml) were taken by venepuncture into Monovette syringes (Sarstedt, Leicester), the plasma was separated immediately and transferred to glass containers. Urine samples were collected into polystyrene tubes. All samples were stored at 4 °C for analysis the following day.

Radioimmunoassay

Plasma and urine samples were analysed for the major Δ^9-THC metabolites, viz Δ^9-THC-11-oic acid and its ester glucuronide using the RIA procedure of Law et al (1984a).

Gas-chromatography

Cannabis resin, including that recovered from the cigarette ends, was extracted by ultrasonication with ca 3 ml methanol–chloroform (4:1). Glass fibre filters were cut into small pieces and extracted by refluxing with ethanol for 3 h.

Quantification of THC in the extracts was carried out using the gas-chromatographic procedure of Baker et al (1980).

RESULTS

The 6 cigarettes contained a total of 102·6 mg THC of which 31·4 mg was recovered in the unsmoked cigarette ends. Therefore approximately 71 mg THC was either pyrolysed, absorbed by the smokers, or lost to the room atmosphere where it could be absorbed by the passive subjects.

The plasma and urine cannabinoid concentrations of the six smoking subjects were low. The maximum urine and plasma cannabinoid metabolite concentrations were 60 and 7·5 ng ml^{-1} respectively (both in the same subject). The other five subjects gave mean maxima of 19 and 2·5 ng ml^{-1} respectively. If allowance is made for the difference in bioavailability of THC by the oral and smoking routes, total cannabinoid concentrations attained in the smokers would have been expected to exceed those previously reported in experiments in which THC was administered orally (Law et al 1984b). In that experiment, plasma total cannabinoid concentrations reached 200 ng ml^{-1} and in urine they ranged up to 1000 ng ml^{-1}. Thus, it can be assumed that the smokers absorbed little of the available THC, most being lost in the side-stream smoke or exhalations. Apart from two subjects who exhibited faintness and nausea, none reported any cannabis-related effects. The two subjects who reacted adversely had used cannabis previously and obtained the highest body fluid cannabinoid levels despite their smoking less than half of the cigarettes.

Analysis of the air filters confirmed the presence of THC in room air at concentrations of 0·2 and 0·06 μg $litre^{-1}$ at 35 min and 75 min respectively, after the start of smoking. If an average THC concentration in the air of 0·5 μg $litre^{-1}$ is assumed over the first hour of the experiment, then the passive inhalers with a respiration rate of 8·5 litres min^{-1} would have inhaled approximately 250 μg THC during that hour. However, it is likely that only a small proportion of this dose was actually absorbed and probably even less during the remaining 2 h of the experiment.

No cannabinoids were detected in the plasma samples of any of the passive inhalers taken up to 3 h after the start of the smoking procedure. But urine samples showed low, but significant, concentrations of cannabinoid metabolites (Table 1). None of the passive inhalers experienced subjective effects associated with cannabis intoxication.

DISCUSSION

This experiment clearly demonstrates that passive inhalation of cannabis smoke, under conditions

Table 1. Concentrations of cannabinoid metabolites detected by RIA in the urine of 4 subjects exposed as passive inhalers to cannabis smoke.

Approximate time after start of smoking (h)	Urine concentration (ng ml^{-1})			
	I	II	III	IV
Pre-exposure	0·1	0·4	0	0
1	1·1	1·4	0·4	0·5
2	1·3	5·5	5·3	3·8
4·5	0·9	5·6	6·6	5·8
6	0·8	3·7	5·4	6·8

Normal cut-off for the RIA is 2 ng ml^{-1} which gives a >99·7% certainty of a true positive result (Law et al 1984a).

Table 2. Experimental conditions and cannabinoid body fluid concentrations following passive inhalation of cannabis smoke.

Δ⁹-THC burnt (mg)	Room size (litres)	Number of subjects	Period of exposure (h)	Analyt. method	Body fluid	Compounds[6] detected	Time after exposure	Concn (ng ml^{-1})
34[1]	39 600	4	2·5	RIA, Emit	urine	TA + TAG	up to 4 h	0
34[1]	39 600	4	2·5	RIA	plasma	TA + TAG	up to 60 min	0
90[2]	small car	ND[8]	ND[8]	Emit, RIA	urine	TA + TAG	up to 1 day	>20
90[2]	small car	ND[8]	ND[8]	GC/MS	plasma	T	0	1·3–6
52[3]	15 500	2	1	Emit	urine	TA + TAG	up to 24 h	0
52[3]	3 500[7]	2	1	Emit	urine	TA + TAG	6 h	20
105[4]	15 500	1	1	RIA, GC/MS	plasma	T	5 min	<2·2
105[4]	15 500	1	1	RIA	plasma	TA	9–60 min	>1
70[5]	27 950	4	3	RIA	urine	TA + TAG	up to 6 h	≤6·8
70[5]	27 950	4	3	RIA	plasma	TA + TAG	up to 3 h	0

[1] Law, B., Mason, P. A. and Moffat, A. C. 1980 unpublished results.
[2] Wethe et al (1982).
[3] Perez-Reyes et al (1983).
[4] Mason et al (1983).
[5] This study.
[6] T = Δ⁹-THC, TA = Δ⁹-THC-11-oic acid, TAG = Δ⁹-THC-11-oic acid glucuronide.
[7] In this experiment the 'room' was a station waggon.
[8] No data given.

similar to those met in social cannabis use, will lead to significant urinary cannabinoid concentrations of about 5 ng ml^{-1}. However, no cannabinoids could be detected in plasma samples from the same subjects.

The urine findings were above the 2 ng ml^{-1} normally used to discriminate between positive and negative results obtained using this assay (Law et al 1984a). The inference that a person has used cannabis, based solely on a positive result from urine analysis, is therefore invalid. Although assay cut-off levels can be raised to eliminate those results likely to be due to passive inhalation, practical problems exist in the determination of reliable maximum cannabinoid levels from passive inhalation and any data are likely to be equivocal.

The results from the present experiment, along with other published and unpublished work (see Table 2), highlight the problems faced by forensic toxicologists in the field of cannabinoid analysis of biological fluids. The conditions in this experiment, i.e. room size, mass of THC etc. were designed to mimic a real situation. However, as cannabis cigarettes tend to be smoked one or two at a time and passed around, the simultaneous smoking of six cigarettes in this experiment would obviously enhance passive inhalation, also, a positive result from such an experiment is highly dependent on the analytical technique used and the cannabinoid compounds detected. In a similar preliminary experiment where four subjects were seated in a room in which five cannabis cigarettes (each containing 6·8 mg THC) were burned, negative results were obtained from their urine samples. One of the reasons for the disparity in these results was the different RIA procedures used. The ^{125}I-RIA employed in the present study gives urine cannabinoid values about four times higher than the assay of Williams et al (1979) used in the preliminary experiment. This discrepancy highlights the problem of comparing the results from two methods even when they possess similar specificities.

The available data on passive inhalation of cannabinoids are summarized in Table 2 and may help in interpreting case findings. Given the low blood concentrations achieved and the rapid metabolism of THC, it is unlikely that THC would be detected in plasma samples submitted for forensic analysis from passive inhalers. The available data also suggest that under similar circumstances the detection of metabolites of THC in plasma is also unlikely.

The interpretation of urine cannabinoid concentrations in relation to passive inhalation is more difficult. The amounts of cannabinoids detected are clearly dependent on the concentration of smoke which would be a function of room size, mass of THC smoked (as well as the analytical technique) and ventilation.

Acknowledgements
We thank Dr R. Cramn of the University of Surrey for technical assistance, and the Laboratory of the Government Chemist for supplying cannabis resin.

REFERENCES

Baker, P. B., Taylor, B. J., Gough, T. A. (1980) J. Pharm. Pharmacol. 33: 369–372

Feyerabend, C., Higenbottom, T., Russell, M. A. H. (1982) Br. Med. J. 284: 1002–1004

Fish, F., Wilson, W. D. C. (1969) J. Forens. Sci. Soc. 9: 37–40

Horning, E. C., Horning, M.G., Caroll, D. J., Stillwell, R. N., Dzidic, I. (1973) Life Sci. 13: 1331–1346

Law, B., Mason, P. A., Moffat, A. C., King, L. J. (1984a) J. Anal. Toxicol. 8: 14–18

Law, B., Mason, P. A., Moffat, A. C., King. L. J. (1984b) J. Pharm. Pharmacol. 36: 289–294

Mason, A. P., Perez-Reyes, M., McBay, A. J., Foltz, R. L. (1983) J. Anal. Toxicol. 7: 172–174

Perez-Reyes, M., Guiseppi, S. Di, Mason, A. P., Davis, K. H. (1983) Clin. Pharmacol. Ther. 34: 36–41

Truitt, E. B. (1971) Pharmacol. Rev. 23: 273–278

Wethe, G., Bugge, A., Bones, T., Morland, J., Skuterud, B., Steen, A. (1982) Acta. Pharmacol. Toxicol. 51: 21

Williams, P. L., Moffat, A. C., King, L. J. (1979) J. Chromatogr. 186: 595–603

Zeidenberg, P., Bourdon, R., Nahas, G. G. (1977) Am. J. Psychiatry, 134: 76–77