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The Significance of Drug Analysis of Sweat in Respect to Rapid Screening for Drug Abuse

I. Ishiyama[1], To. Nagai[1], Ta. Nagai[1], E. Komuro[1], T. Momose[1], and N. Akimori[2]

[1] Dept. of Forensic Medicine, Teikyo University School of Medicine, 173–Tokyo, Itabashiku, Kaga
[2] Application Laboratory of Nakawork, Hitachi Co. Ltd., Japan

Summary. Morphine and methamphetamine, which are excreted in the sweat, are detected by the use of routine serological and physicochemical techniques for urinary examinations. Screening for drug abuse can be done with the same accuracy of that of urine. Rapid excretion of the drug via kidney (within one day) is followed by a slow but steady excretion of the sweat gland. Methamphetamine given orally in a dosis of 10 mg is excreted in the sweat at a constant rate (1.4 μg/ml). No significant difference of the amount excreted by both systems is found. Alveolar lining seems to prevent the elimination of the volatile methamphetamine via respiration. Not only narcotics and stimulants, but also many alkaloids and barbiturates are excreted in the sweat and detected quantitatively by the same principles. The toxicological analysis of the sweat promises a new scope of forensic investigation.

Key words: Morphine – Methamphetamine – Sweat analysis – Drug abuse, rapid screening

Zusammenfassung. Die Verfahren, die das Vorhandensein von Morphin und Methamphetamin im Schweiß feststellen können, wurden berichtet. Die immunochemische, sowie gaschromatographische Analyse der Schweißflüssigkeit der Vergifteten, die sich durch das Wischen der Haut mit dem benetzten Handtuch gewinnen läßt, brachten den meisten Fällen sichere Ergebnisse, so daß die Schweißanalyse, genau wie die Urinuntersuchung, für die Screeningtests bei Vergifteten angewandt werden kann. Es wurde auch festgestellt, daß die Untersuchung von Unterhemd und Strümpfen, die am meisten mit Schweiß benetzt werden, eine sichere Information über die Möglichkeit der Vergiftung geben.

Der Vergleich der Amphetaminausscheidung im Schweiß und Urin wurde durchgeführt. Obwohl die Menge des Amphetamins im Schweiß wegen der Schwierig-

Offprint requests to: I. Ishiyama, M.D. (address see above)

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keit der Sammlung ziemlich gering eingeschätzt wird, läßt sich das Mittel mit konstantem Verhältnis via Transpiration ausscheiden. Die absolute Menge, die im Schweiß und Urin ausgeschieden wird, ist gleich. Eine Beeinflußung der Amphetaminausscheidung wie bei alkalischem Medium des Urins, kann bei Schweiß nicht beobachtet werden. Die Untersuchung der ausgeatmeten Luft von Vergifteten, die 10 mg Amphetamin eingenommen haben, ergab negative Ergebnisse. Die Bedeutung der Schweißanalyse in der forensischen Toxikologie wurde besprochen.

Schlüsselwörter: Morphin – Methamphetamin – Schweißanalyse – Drogenmißbrauch, Sehnenanalysen

Although an increase in the number of physicochemical and serological tests [1] have provided much information as to the determinations and metabolic pathways of various drug intoxications and abuses, some troubles are encountered in cases, in which the patients refuse to deliver the specimens (urine, saliva, etc.). A contribution to device new methods or to seek different kinds of biological specimens is regarded as one of the most enhancing efforts of the investigator, who is participating in chekking the drug abuses and dopings. Recently we have examined the excretion of drugs during perspiration and found that many of them (amphetamines, morphine, nicotine, etc.) are eliminated in the sweat. Furthermore, it was confirmed also that the perspiration plays somewhat important role in the excretion of drug. These results are reported in this paper.

10 mg of morphine hydrochloride or methamphetamine hydrochloride, respectively, was given orally to volunteers. Urine and sweat were collected in certain intervals. The experiment was performed in room temperature (25°C) and no visible perspiration was observed in this condition. The sweat was collected by rubbing the skin surface with a piece of cotton, gauze or towel at a temperature of 50°C. It was then rinsed in 40 ml of distilled water at this temperature for 10 min with an occasional vigorous stirring to wash out the dirt thoroughly. At the same time, the sweat remaining on the socks was extracted in the same way. For the quantitative assessment of the amount of extracted sweat, the electric conductivity of each aliquot was measured to estimate its salt concentration. For the detection of morphine, the sweat extract was freeze-dried or condensed with the aid of rotatory evaporation at 60°C (the salt concentration was checked to keep the level, in which no interference occurred in enzyme immunoassay test). Homogeneous enzyme immunoassay (EMIT® of Syva Co. Ltd., U.S.A.) was used for the tests of the urine and sweat extract. These results were represented in Fig. 1.

It is evident that the examination using the sweat can be performed in routine laboratories with the same accuracy and cut-off level of the urine test. The presence of morphine in the sweat could be confirmed also by gaschromatographic (using OV-17) and gaschromatography-mass spectrometric analysis of the extract according to the method of Wilkinson et al. [2] In cases, in which serological tests give – as our examination of the socks indicates – the value close to the cut-off level, the latter tests should be performed for the purpose of confirmation.

The condensation of the sweat extract by freezedrying or evaporation could not be achieved in examining the methamphetamine because of its highly volatile property. Hence, the drug was extracted according to the method of Jain[3]. Gaschromato-

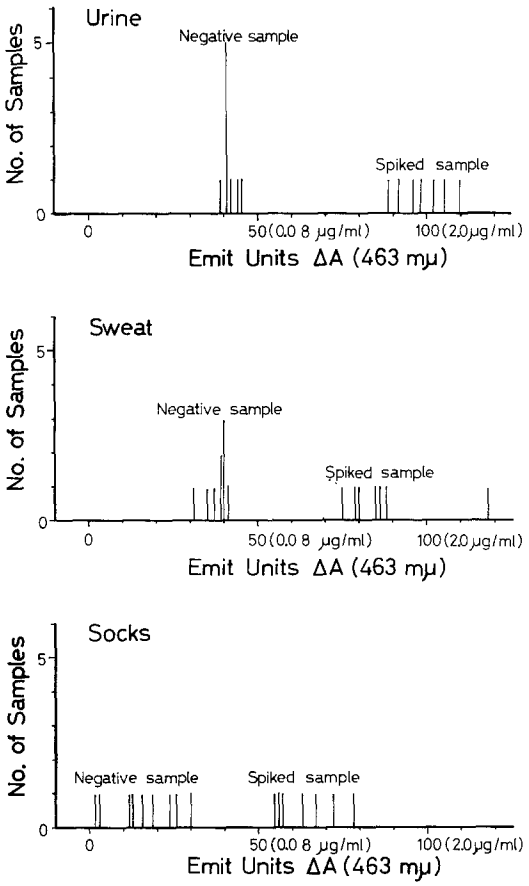

Fig. 1. Comparison of Homogeneous Enzyme Immunoassay (EMIT® for Morphine Assay using three-calibrator system), which was appliced to various biological specimens

graphy was done by applying Hitachi 073 GC and 1.0m x 4mm ϕ glass column of 5% PEG 6000 5% KOH on Chromosorb G (oven temp. 140°C, injection temp. 190° C, detector temp. 180°C, carrier gas: N_2 30 ml/min., pressure of H_2 and air: 0.6 and 1.4 kg/cm^2, respectively). β-phenylethylamine was used as an internal standard. The procedure revealed following points [1]; the urine of healthy non-smokers gives no response in scanning the gaschromatography for 60 min [2], that of smokers responds with the appearance of one predominant peak, which is confirmed as nicotine and [3] the methamphetamine gives a symmetrical peak with the retention time of 2'30".

The fragment pattern of gaschromatographic peak, corresponding to the methamphetamine, was confirmed by the Hitachi GC-MS (RMU-6MG, column 3% SE-30 glass 1.0m x 3mm ϕ, oven temp. 200°C, separation temp. 250° C, carrier gas: He 0.8 kg/cm^2, ionizing voltage 20 eV, accerelation voltage 3.2 kV and ion source temp. 180°C). The elimination pattern of the methamphetamine by the perspiration and urination was shown in Fig. 2.

It was also ascertained, as Table 1 demonstrates, that the excretion of the drug into the sweat – it reaches roughly to the total amount of the elimination in the urine – is fairly constant in comparing with the urine excretion, which is affected

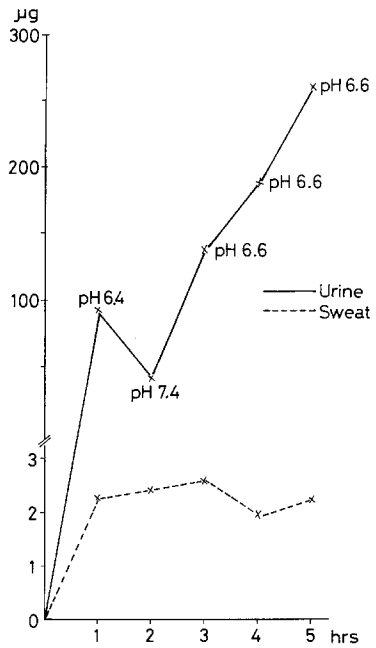

Fig. 2. Excretion Pattern of Methamphetamine in the Urine and Sweat. Ordinate: Total amount of excreted methamphetamine. Abcissa: Time after the methamphetamine administration. (Methamphetamine was administered with a peroral dosis of 10 mg. The sweat was collected from both forearms and hands)

Table 1. Total amount of methamphetamine excreted in the sweat and urine after oral administration of 10 mg

Time after administration (Hour)	Total amount excreted in Urine (μg)	Conc. in urine (μg/ml)	Total amount[a] excreted in Sweat (μg)	Conc. in sweat (μg/ml)	Total amount excreted (μg)	Elimination rate of sweat
1	93.6	1.87	19.4	0.88	113	0.17
2	40.6	0.74	22.7	1.03	63.3	0.36
3	137.9	2.76	30.1	1.37	168	0.18
4	187.2	1.97	30.4	1.38	217.6	0.14
5	262.3	3.75	31.2	1.42	293.5	0.10
6–23	1540	1.76	(677)		2217	
24	33	0.66	27.7	1.26	60.7	0.46
25–47	(470)		(576)		1046	
48	7.8	0.12	22.4	1.02	30.2	0.74
49–71	(161)		(490)		651	
72	6.2	0.10	20.2	0.92	26.4	0.77
73–95	(trace)		(405)		405	
96	trace		15.0	0.68		
97–119	(none)		(262)			
120	none		7.8	0.35		
121–143	(none)		trace			
Total Amount	ca. 2.9 mg		ca. 2.4 mg		ca. 5.3 mg	0.45

a Total amount excreted in the sweat was calculated by multiplying the concentration with 22 ml (excretion rate of sweat per one hour from the total body surface, assuming that the salt concentration is 0.85%)
The number in the bracket means the value obtained from the average level between two time intervals

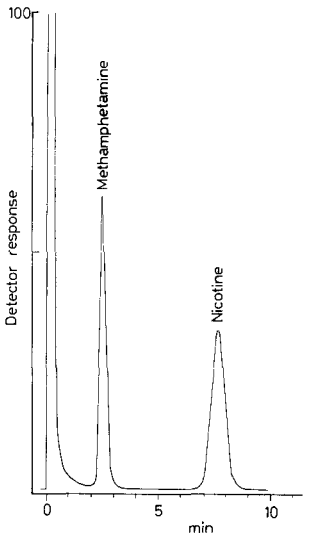

Fig. 3. Gaschromatographic Pattern of the Sweat Extract Obtained from the methamphetamine-addicted individual (one μl of the chloroform extract was injected into GC. Detector condition was Range 10 x Attenuation 4)

remarkably in various situations (pH change, etc.). The concentration of the drug in the sweat was about 1.4 μg/ml in a steady state. This characteristic feature of drug elimination persists even at a later stage, in which the elimination of the drug into the urine became scanty. Thus, the elimination rate of methamphetamine into the sweat increases as the time passes, and the drug tends finally to be excreted solely in the perspiration.

Figure 3 represents the actual case of the methamphetamine addict, in which the patient refused the urine examination.

The amount of the methamphetamine in the sweat, which was collected from the face, neck, and the upper extremities, was 170 μg; this is presumably an amount of the methamphetamine excreted in the sweat within one day (postulation: the amount of the sweat excretion in one day is 500 ml and the concentration of the drug in the sweat 1.4 μg/ml, then the amount of the drug eliminated during perspiration can be calculated 500 x 1.4 x 0.25 =175 μg, assuming the regions under examination being 25% of total body surface).

Investigation of the socks contaminated with the sweat of methamphetamine-addicted individuals revealed the same results of sweat sampling. Another possibility of excretion, i.e., elimination of volatile methamphetamine by respiration can be omitted as the expired air (100 1) contains no trace of the drug in testing the addicted individuals. The surface membrane of phospholipoprotein on the alveolar lining is presumably responsible for this barrier mechanism.

No accurate investigation have been performed concerning the quantitative excretion of drugs into the sweat except for several descriptions of clinical and forensic experiences 4, 5, 7. It was confirmed that the excretion of the drug in the sweat may be the same level of the urinary excretion. Especially, the excretion of the methamphetamine via perspiration – it may be rather negligible in a state of intoxication, in which the excretion into the urine is prevailing – must be indispensable in eliminating the scanty amount of substances below the level of tubular reabsorption. Recent informations of the receptor mechanism for the selective uptake of the cells

lead some contradictions as to the metabolic fate of toxic substances; i.e., what mechanism can be postulated concerning the elimination of these substances in a state of complete reabsorption? If they were reabsorbed and had no other elimination systems, they would act for a longer period than expected, until they were completely detoxicated in vivo. Such situation would be avoided by the presence of a supplementary system, which acts effectively for the selective excretion of low amount of toxic substance. From this view point, it may be interesting to compare the receptor systems of renal tubuli and coil cells of the sweat gland.

Another important aspect of our investigation is its application in the field of criminology. The range of criminal investigation can be extended not only in testing the drug abuses or doping individuals, but also in testing the specimens of trace evidence in relation to the sweat research in the fields of serology [6] and toxicology. The advantages that the drug is detected in the sweat for a longer period than urine and the sampling of the specimens is achieved with less psychic and somatic resistance of the individuals are more convenient for the screening of drug abuses, etc.

Our results are not confined in detecting only these two drugs. Various kinds of narcotics and stimulants, which have common chemical structures, are excreted in the sweat and detected by the same principles. It is possible that many toxic organic substances (alkaloids, barbiturates, etc.) can be determined quantitatively in analyzing the sweat. In this sense, the forensic toxicology will be fortified, together with the previous urine examination, by a new scope of the research field and practical application.

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