〈Regular Article〉

Methamphetamine concentrations in blood and gastric contents in 20 forensic autopsy cases

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ABSTRACT Methamphetamine is one of the most commonly abused drugs and cases of methamphetamine-related death are not uncommon. In forensic autopsy cases, it is important to identify how a detected drug was taken to confirm whether an illegal substance was self-administered or possibly administered unknowingly. The present study involved 20 forensic autopsy cases examined at Okayama University between 2012 and 2020 in which methamphetamine was detected. In each case, methamphetamine concentrations in blood and gastric contents, along with other factors such as age, postmortem interval, and cause of death, were investigated, and the ratio of the methamphetamine concentration in gastric contents to that in blood (GB ratio) was determined. No correlations were observed between the GB ratio and age, postmortem interval, methamphetamine concentrations in peripheral blood and gastric contents, volume of gastric contents, or total amount of methamphetamine in gastric contents. A good correlation was observed between methamphetamine concentrations in peripheral blood and in gastric contents. The maximum GB ratio was 58.8 in a case in which it was suspected that there had been prolonged general prostration before death. In cases without prolonged general prostration, the maximum GB ratio was 26.8, which was less than the value of 36 that was previously reported as the threshold for judging whether the methamphetamine detected was taken orally.

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Key words：Methamphetamine, Administration route, Drug concentration, Gastric contents

INTRODUCTION

Methamphetamine is a powerful, highly addictive stimulant that affects the central nervous system, and it is a commonly abused drug in East Asia[1]. In Japan, methamphetamine is one of the most commonly abused drugs, and methamphetamine-related forensic autopsy cases are not uncommon.

Since willfully taking methamphetamine is illegal in Japan, in forensic autopsy cases, it is important to identify how a detected drug was taken to confirm whether an illegal substance was self-administered

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or possibly administered unwillingly, such as in a spiked drink. Accordingly, we are attempting to develop a method for determining the route of methamphetamine intake based on a comparison of drug concentrations in gastric contents and blood.

It was expected that drug concentrations in gastric contents would be very high immediately after oral intake of a drug, but that the concentration would be very low after parenteral administration. A previous study showed that the drug concentrations in gastric contents were very high in some cases, and the total amount of a drug in gastric contents has been used to estimate the minimum amount of the drug taken[2]. However, in the case of some basic drugs, including methamphetamine, it has been reported that the drug concentrations were higher in gastric contents than in blood even when they were administered intravenously[3, 4]. An animal study using rats actually showed that the methamphetamine concentration in gastric contents increased immediately after administration, despite the fact that the administration route was parenteral[5].

This result of the drug concentration in gastric contents becoming higher than that in blood was one of the most important problems with the method of determining the drug intake route by using its concentrations in gastric contents and blood. At least, this fact suggested that, just because the methamphetamine concentration in the stomach contents was higher than that in the blood did not mean that the methamphetamine administration route was oral.

However, animal experiments also showed that the ratio of methamphetamine concentration in gastric contents to blood did not exceed 58.8, which suggested the possibility of estimating the route of methamphetamine intake[5].

Nevertheless, these previous results were based solely on animal experiments, and the relationships between methamphetamine concentrations in gastric contents and blood in humans have not been clarified. Thus, it was considered important to compare methamphetamine concentrations in blood and gastric contents in actual human autopsy cases. Therefore, this study was performed to compare methamphetamine concentrations in blood and gastric contents, along with other factors, such as age, postmortem interval, and cause of death, in 20 forensic autopsy cases examined at Okayama University between 2012 and 2020 in which methamphetamine was detected.

MATERIALS AND METHODS

Twenty autopsy cases in which the deceased had taken methamphetamine subcutaneously or intravenously were investigated. Since it was difficult to identify the actual route of administration of methamphetamine at autopsy, when a relatively new needle mark on the deceased was identified or there was a syringe containing methamphetamine near where the deceased was found, the deceased was judged to have taken methamphetamine by injection. All samples collected at autopsy were immediately stored at -30℃ .

REAGENTS

Methamphetamine hydrochloride (Philopon) and methoxyphenamine hydrochloride were purchased from Sumitomo Dainippon Pharma Co., Ltd. (Osaka, Japan) and Sigma-Aldrich Japan (Tokyo, Japan), respectively. All other chemicals used were of reagent grade.

METHAMPHETAMINE ANALYSIS

Methamphetamine analysis was performed by gas chromatography-mass spectrometry, as previously described[5].

STATISTICAL ANALYSIS

All statistical analyses were performed with IBM SPSS Statics (ver 28.0.1).

RESULTS AND DISCUSSION

Age, sex, postmortem interval, methamphetamine concentrations in the peripheral blood and gastric contents, the ratio of the methamphetamine concentration in gastric contents to that in blood (GB ratio), volume of gastric contents, total amount of methamphetamine in gastric contents, and the causes of death are summarized in Table 1. Correlation coefficients were determined for each variable to determine possible relationships among the obtained data.

This study included 18 male and 2 female cadavers, with age at death ranging from the twenties to the seventies, and postmortem intervals ranging from 0.4 to 7.0 days (mean 2.2 days). In all cases, the cadavers were either not or only slightly putrefied.

The ages at death of the individuals were almost equally distributed (20s, three; 30s, four; 40s, six; 50s, three; 60s, three; 70s, one), and no correlation between the GB ratio and age was observed (Fig. 1). Although the maximum postmortem interval was 7 days, blood was still retrievable in each case, and putrefactive effects were limited because all cadavers were found during cold seasons and were kept in a refrigerated chamber from when found until the autopsy was performed. The maximum blood methamphetamine concentration in these cases was 14.6 μg/mL, and only this value

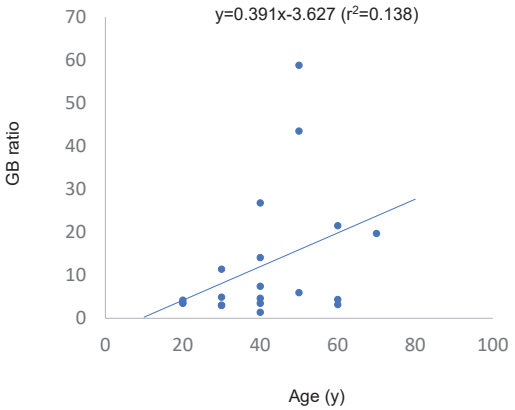

Fig. 1. Correlation between age and the GB ratio

Table 1. Characteristics of the autopsy cases.

Case	Age (y)	Sex	Postmortem interval (days)	Methamphetamine concentration (μg/mL or g)		Ratio of methamphetamine concentrations (gastric contents/ peripheral blood)	Volume of gastric contents (mL)	Total amount of methamphetamine in gastric contents (μg)	Cause of death
				Peripheral blood	Gastric contents				
1	30	Male	1.6	0.0270	0.132	4.89	70	9	Hanging
2	50	Male	7.0	0.0366	1.59	43.5	60	95	Unknown
3	20	Male	1.8	0.105	0.441	4.20	150	66	Unknown
4	40	Male	2.5	0.236	0.816	3.46	500	408	Multiple drug poisoning
5	70	Male	2.0	0.316	6.23	19.7	170	1,059	Death due to fire
6	50	Male	1.8	0.340	20.0	58.8	250	5,000	Unknown
7	40	Male	1.5	0.347	9.29	26.8	20	186	Intraventricular hemorrhage
8	40	Male	4.0	0.530	3.93	7.43	780	3,065	Unknown
9	40	Male	0.4	0.551	7.76	14.1	200	1,552	Heroin poisoning
10	40	Male	2.5	0.817	3.79	4.64	30	114	Death due to fire
11	20	Male	0.7	0.929	3.34	3.60	200	668	Thermoplegia
12	20	Female	1.3	1.01	3.49	3.46	170	593	Subarachnoid hemorrhage
13	30	Male	0.6	1.23	3.73	3.03	170	634	Suspected methamphetamine poisoning
14	50	Male	7.0	1.37	8.14	5.94	160	1,302	Suspected methamphetamine poisoning
15	60	Male	0.5	1.43	4.52	3.16	300	1,356	Death from cold
16	60	Male	2.5	1.61	34.60	21.5	140	4,844	Lobar pneumonia
17	60	Male	1.0	2.65	11.6	4.36	330	3,828	CO poisoning
18	40	Female	1.9	3.11	4.28	1.38	400	1,712	Methamphetamine poisoning
19	30	Male	2.8	4.18	47.6	11.4	220	10,472	Asphyxia
20	30	Male	1.0	14.6	43.4	2.97	30	1,302	Methamphetamine poisoning

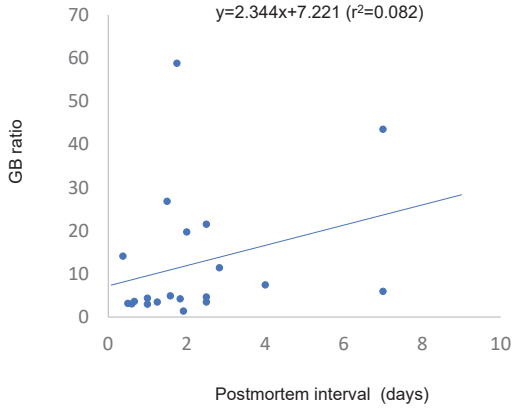

Fig. 2. Correlation between the postmortem interval and the GB ratio

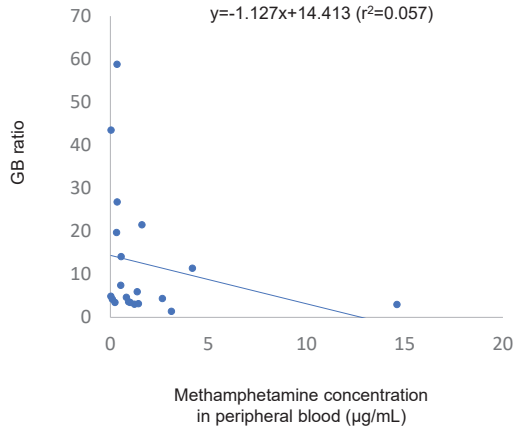

Fig. 3. Correlation between the methamphetamine concentration in peripheral blood and the GB ratio

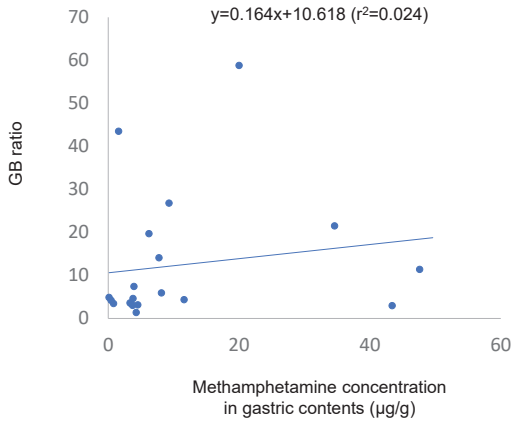

Fig. 4. Correlation between the methamphetamine concentration in gastric contents and the GB ratio

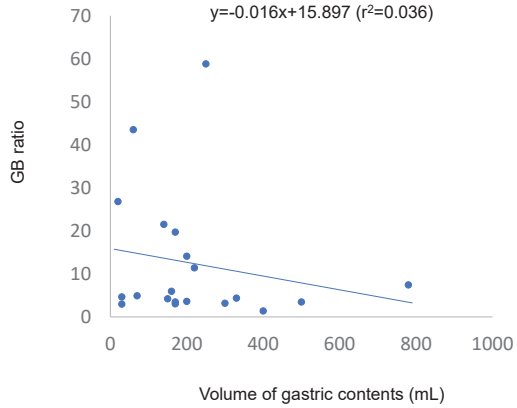

Fig. 5. Correlation between the volume of gastric contents and the GB ratio

reached the lethal dose[6]. In other cases, blood methamphetamine concentrations were in the borderline region or less than the lethal dose[6].

It is very difficult to identify the route of administration of a drug on a cadaver because usually there are very poor signs or no signs of the route. Thus, new needle mark(s) on the cadaver and/or syringe(s) containing methamphetamine found near the deceased were regarded as indicating that the deceased had injected the methamphetamine.

Though it was suspected that some of the deceased had taken methamphetamine subcutaneously or intravenously, and not orally, the methamphetamine concentrations in gastric contents were higher than in blood in all cases. The methamphetamine concentrations in blood and gastric contents were 0.0270-14.6 μg/mL (mean 1.77 μg/mL) and 0.132-47.6 μg/mL (mean 10.9 μg/mL), respectively, the GB ratios were 1.38-58.8 (mean 11.9), the volumes of gastric contents were 20-780 mL (mean 218 mL), and the total amounts of methamphetamine in gastric contents were 9.24-10,472 μg (mean 1,913 μg).

No correlations were observed between the GB

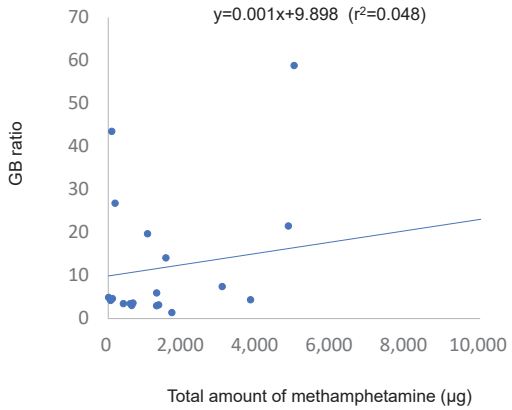

Fig. 6. Correlation between the total amount of methamphetamine in gastric contents and the GB ratio

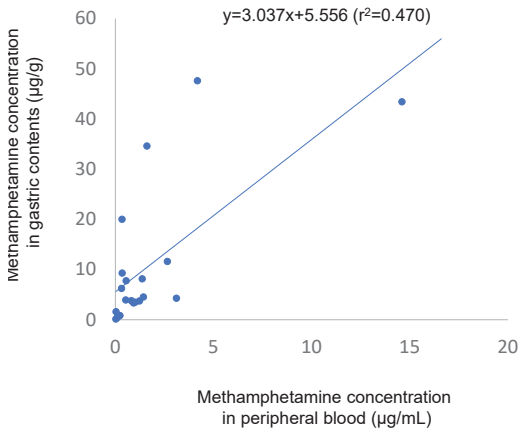

Fig. 7. Correlation between the methamphetamine concentration in peripheral blood and gastric contents

ratio and the postmortem interval, methamphetamine concentrations in peripheral blood and gastric contents, volume of gastric contents, and total amount of methamphetamine in gastric contents (Figs. 2-6).

In a previous study of human autopsy cases, a very good correlation of the methamphetamine concentrations in blood and gastric contents was observed[4]. A good correlation was also observed in the present study (Fig. 7).

According to the previous animal study on subcutaneous administration of methamphetamine in rats, the maximum GB ratio was 54.2[5]. In the present human autopsy cases in which methamphetamine was detected, the maximum GB ratio was 58.8 and the second highest value was 43.5 (Table 1). In these two cases with high GB ratios, prolonged general prostration before death was suspected. Such a condition might have led to deterioration of gastric movement and retention of gastric contents in the stomach, resulting in accumulation of methamphetamine; however, blood methamphetamine concentrations would have decreased while blood circulation was maintained.

A previous report suggested that a GB ratio ≥ 36 indicated the deceased had taken the methamphetamine orally[4]. The present study confirmed that this threshold seemed to be appropriate because, excluding the two cases in which prolonged general prostration before death was suspected, the maximum GB ratio was 26.8

The minimum GB ratio in the present study was 1.38, compared to 1.18 in previous animal experiments[5], and both of these values are very different from the maximum values. Since the reason for this large variation in GB ratios remains unclear, additional studies are needed to identify factors causing these differences, with the goal of developing a method for determining the route of methamphetamine intake based on a comparison of drug concentrations in gastric contents and blood.

Ethical approval for this study was obtained from the ethics committee of Kawasaki Medical School (5621-00).

The authors declare that they have no conflict of interest.

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