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# Postmortem Computed Tomographic Analysis of Death Caused by Oral Drug Intoxication

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Traditional autopsy has changed little in the past century. In Japan, the rate of forensic autopsy in cases of unusual death is very low. Therefore, multi-slice computed tomography (CT) has been used to obtain imaging data instead of or in addition to autopsy in suspicious forensic cases. In our institute, postmortem multi-slice CT has been performed since 2009, and by 2014 there were over 1,000 cases. Our extensive experience with postmortem CT shows that in many cases of death by drug overdose, stomach contents exhibit high X-ray absorption. This article reviews the relationship between CT findings of stomach contents and toxicological analysis results in 23 cases of death by drug overdose. All cases (12 females and 11 males, aged 44 ± 11 years) known to have orally ingested drugs were included in this study. We assessed the slices of all stomach areas on consecutive axial CT images. Twenty cases (87%) showed high X-ray absorption in the stomach, while the other three did not demonstrate radio-dense stomach contents even though drug analysis detected lethal concentrations of drugs in the blood. In conclusion, drugs were frequently, but not always, visualized as contents with high X-ray absorption in the stomach. Postmortem gastric CT images can provide useful information in cases of oral drug intoxication if there are empty drug packages or a suicide note at the death scene. However, precise determination of the cause of death requires full autopsy in cases where there is no indication of suicide at the death scene.

**Keywords:** drug overdose; forensic autopsy; high X-ray absorption; postmortem computed tomography; stomach contents.
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## Introduction

Traditional autopsy has changed little in the past century, consisting of external examination and evisceration, and dissection of the major organs with identification of macroscopic pathologies and injuries (Roberts et al. 2012). In Japan, the rate of forensic autopsy in cases of unusual death is very low. Therefore, multi-slice computed tomography (MSCT) has been used to obtain imaging data instead of or in addition to autopsy in forensic cases. Over the past few years, more than 20 forensic institutes in the 90 Japanese schools of medicine have acquired computed tomography (CT) scanners for use in forensic autopsy cases. In our institute, postmortem MSCT has been performed as part of pre-autopsy screening since 2009. By 2014 we experienced over 1,000 cases of postmortem CT scanning and reported postmortem radiologic features of hypothermic death (Kawasumi et al. 2013) and drowning (Usui et al. 2014).

In many cases of death by drug overdose, CT findings of stomach contents demonstrate high X-ray absorption. Burke et al. (2012) evaluated CT images of gastric contents in 61 cases of death by drug overdose. They found that a well-defined basal sedimentation layer, characterized by clear and abrupt radio-dense material compared with adjacent gastric contents, was frequently seen in the gastric contents; however, there was no information on either the types of medications involved in these cases or the blood drug concentrations. In the present study, we reviewed the relationship between CT findings of stomach contents and toxicological analysis results in 23 cases of death by drug overdose.

## Materials and Methods

*Materials*

Consecutive forensic autopsy cases (n = 717) from April 2010 to March 2014 at our institute were retrospectively enrolled for analysis of gastric contents by postmortem CT and autopsy. A total of 23

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Table 1. Case backgrounds and blood drug concentrations.

| No. of case | Case backgrounds | | | | | | Blood drug concentration |
|---|---|---|---|---|---|---|---|
| | Sex | Age (years) | Pre-existing disorder | Many empty drug packages | Suicide note | Others | |
| 1 | F | 30 | Depression | | | | Amobarbital 13 μg/ml*<br>Phenobarbital 122 μg/ml*<br>Pentobarbital 11 μg/ml** |
| 2 | M | 50 | | + | | Amphetamine detected in urine | Triazolam 100 ng/ml* |
| 3 | F | 32 | | + | | Obesity (150 cm, 94 kg) | Levomepromazine 3.0 μg/ml* |
| 4 | F | 47 | PTSD and panic disorder | + | | Blood alcohol level was 0.2 mg/ml | Diphenhydramine 10.2 μg/ml*<br>Mianserin 443 ng/ml**<br>Zolpidem 199 ng/ml** |
| 5 | M | 53 | | | | | Amobarbital 87 μg/ml* |
| 6 | M | 53 | Bipolar disorder | | | | Pentobarbital 414 μg/ml* |
| 7 | F | 39 | Unstable personality disorder | + | | | Zolpidem 917 ng/ml* |
| 8 | F | 45 | | | | | Pentobarbital 33 μg/ml*<br>Levomepromazine 631 ng/ml**<br>Nitrazepam 225 ng/ml** |
| 9 | M | 52 | | | | Blood alcohol level was 1.1 mg/ml | Zopiclone 1720 ng/ml* |
| 10 | M | 38 | Schizophrenia | | | | Milnacipran 19 μg/ml*<br>Zolpidem 1180 ng/ml*<br>Paroxetine 904 ng/ml** |
| 11 | M | 38 | Alcoholism | + | + | Blood alcohol level was 0.5 mg/ml | Levomepromazine 2100 ng/ml*<br>Olanzapine 1060 ng/ml*<br>Phenobarbital 80 μg/ml*<br>Zopiclone 659 ng/ml** |
| 12 | F | 64 | Mental disorder | | | | Olanzapine 1020 ng/ml* |
| 13 | M | 40 | | + | | Hesitation marks found on the wrist. | Salicylic acid 429 μg/ml* |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14 | M | 31 | | + | + | | Olanzapine 247 ng/ml*<br>Zolpidem 330 ng/ml** |
| 15 | F | 36 | | | | Hypnotics were taken | Amobarbital 14.8 μg/ml*<br>Pentobarbital 17.8 μg/ml*<br>Triazolam 7.4 ng/ml** |
| 16 | F | 36 | Schizophrenia | + | | Vomitus was present around the mouth | Levomepromazine 949 ng/ml*<br>Haloperidol 59 ng/ml** |
| 17 | M | 52 | Depression | + | | | Flunitrazepam 106 ng/ml* |
| 18 | F | 31 | Dissociative disorder and depression | + | | | Amitriptyline 6060 ng/ml*<br>Nortriptyline 902 ng/ml* |
| 19 | F | 42 | Schizophrenia | | | | Olanzapine 406 ng/ml*<br>Phenobarbital 154 μg/ml*<br>Promethazine 977 ng/ml** |
| 20 | F | 43 | Depression and panic disorder | + | | | Levomepromazine 3890 ng/ml*<br>Mirtazapine 6020 ng/ml*<br>Zolpidem 332 ng/ml** |
| 21 | M | 72 | Schizophrenia | + | | | Promethazine 245 ng/ml**<br>Sulpiride 2170 ng/ml*** |
| 22 | M | 59 | | + | + | | Levomepromazine 1880 ng/ml*<br>Promethazine 919 ng/ml**<br>Zopiclone 445 ng/ml** |
| 23 | F | 34 | Schizophrenia | + | | | Olanzapine 1100 ng/ml* |

*Lethal dose or exceed toxic range (Baselt 2004; Molina 2010). **Toxic dose (Baselt 2004; Molina 2010). ***Few data of lethal dose, but blood concentration was over therapeutic dose (Baselt 2004; Molina 2010).

M, male; F, female; PTSD, post-traumatic stress disorder; LC-MS/MS, liquid chromatography-tandem mass spectrometry.

cases (12 females and 11 males with a mean age of 44 ± 11 years) known to have orally ingested drugs were included in this study (Table 1). All cases underwent postmortem CT prior to forensic autopsy, which included toxicology analysis. Autopsy findings determined the cause of death as drug overdose in all cases. Cases were excluded if death was caused by intravenous injection, snorting and inhalation of drugs (e.g., amphetamines), hydrogen sulfide poisoning, carbon monoxide poisoning, or pesticide poisoning. The use of postmortem CT images and autopsy records in this study was approved by the ethics board of our institute (2014-1-084, 2015-1-412).

## *Postmortem imaging*

We performed pre-autopsy CT scans with an 8-channel multislice scanner (Aquilion; Toshiba Medical Systems, Tokyo, Japan). The reconstructed CT images are represented as the linear attenuation coefficient map of the scanned object subdivided into a matrix of 512 × 512 picture elements (the linear attenuation coefficient represents the fraction of photons removed from a mono-energetic beam of X-rays per unit thickness of material) (Hsieh 2002). The actual-intensity gray scale used in CT is the CT number, which is measured in terms of Hounsfield units (HUs). The CT number is defined as:

$$\text{CT number [HU]} = 1000 \times \frac{\mu_{\text{object}} - \mu_{\text{water}}}{\mu_{\text{water}}}$$

where $\mu_{\text{object}}$ is the linear attenuation coefficient of the object of interest and $\mu_{\text{water}}$ is the linear attenuation coefficient of water. From the definition, CT number is based on the linear attenuation coefficient value of water (the CT number of water will always be approximately zero HU but not necessarily exactly zero because of quantum mottle). Positive CT numbers indicate that there is more X-ray absorption than in water. For example, a 0.5% attenuation difference corresponds to a CT number difference of 5 HU (Goldman 2007). Volumetric helical scans were obtained from the head to the proximal femur at 120 kVp with variable milliampere-second values (187-225 mAs; these units indicate the product of the X-ray generator tube current and the exposure time, and determine X-ray quantity), a beam pitch of 0.875, a field of view of 500 mm, and a slice thickness of 2.0 mm in 8-slice mode. The volumetric data allowed abdominal reconstructions with soft-tissue kernel settings. The images were viewed as axial slices, multi-planar reconstructions, and three-dimensional (3D) reconstructions using a 3D image workstation server (Ziostation ver. 2.1.5.0; Ziosoft, Tokyo, Japan).

In addition, beginning in April 2012, we began performing postmortem radiography with a mobile plain X-ray system (MobileDaRt; Shimadzu Corp., Kyoto, Japan) integrated with a digital flat-panel detector (CXDI-50G; Canon Inc. Medical Equipment Group, Tokyo, Japan) as part of pre-autopsy screening prior to CT scanning. Thus, plain X-rays were obtained in 14 out of 23 cases. These images were also viewed on an image workstation.

### *Autopsy and dissection of the stomach*

Autopsies were performed by one board-certified forensic pathologist (M.F.) immediately after postmortem CT scanning. Autopsy reports routinely noted stomach contents, including details regarding appearance (with photographic documentation), color, weight, and/or volume. Specimens of stomach contents and peripheral blood were collected for toxicological analysis.

### *Toxicological analysis*

In all 23 autopsy cases, qualitative and quantitative analysis of blood collected from the external iliac vein using liquid chromatography (LC)-tandem mass spectrometry (MS/MS) determined that death was caused by intoxication due to drug overdose. Every case demonstrated lethal, supra-therapeutic drug levels. LC was performed with a Prominence LC system (Shimadzu, Kyoto, Japan). Chromatographic separation was achieved on a CAPCELL-PAK MG II column (35.0 × 2.0 mm id, 5 lm; Shiseido, Tokyo, Japan). MS/MS detection was performed with a 3200 QTRAP system equipped with an electrospray ionization probe (AB Sciex, Foster City, CA). All analyses were performed by the forensic toxicologist (K.U.) in charge of laboratory sample testing at our institution.

### *Assessment of CT images*

We performed a retrospective radiographic analysis of 23 cases in which death was due to intoxication. To evaluate the appearance of the gastric materials, we assessed the slices of all stomach areas, including the fundus, gastric body, and pyloric region, on consecutive axial abdominal CT images. A quite narrow image window (window width, 100 Hounsfield units [HU]; window level, 40 HU) was used to visualize the small differences in X-ray absorption within the gastric contents. One board-certified radiologist (Y.K.) with >10 years of experience and two radiological technologists experienced in postmortem CT (Y.I. and A.U.) evaluated the stomach images of all cases. Images were classified into three groups using Burke's observation method as a reference (Burke et al. 2012): images in which materials with high X-ray absorption and a well-defined layer were clearly present (Group 1) (Fig. 1), possibly present (ill-defined layer with high X-ray absorption) (Group 2) (Fig. 2), and absent (Group 3) (Fig. 3). We also measured CT numbers using the same method (Burke et al. 2012).

The mean, maximum, and minimum CT numbers of the stomach contents were measured in each case on the axial abdominal CT image with the largest area portraying the gastric materials. In this

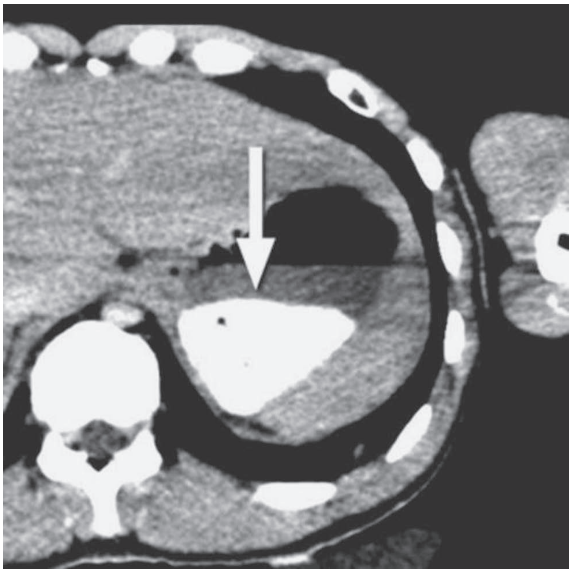

Fig. 1. Postmortem abdominal CT image of Group 1.
Abdominal axial CT image of Case 10 shows well-defined stomach contents with high X-ray absorption (arrow).

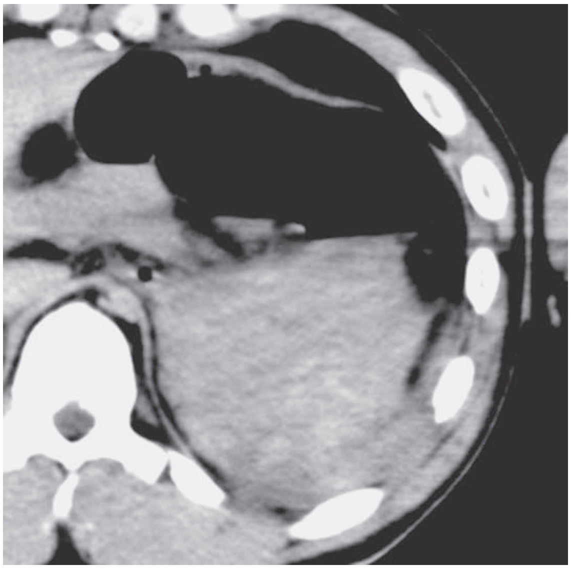

Fig. 2. Postmortem abdominal CT image of Group 2. Abdominal axial CT image of Case 1 shows ill-defined materials with high X-ray absorption throughout the entire stomach.

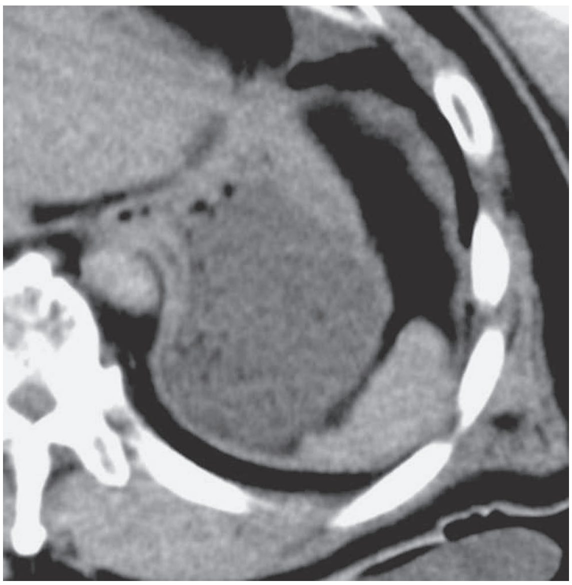

Fig. 3. Postmortem abdominal CT image of Group 3. Abdominal axial CT image of Case 17 shows no materials with high X-ray absorption.

study, the values of CT numbers were rounded off to the nearest whole number. The CT numbers of gastric contents were measured in user-defined regions of interest (ROIs) on abdominal CT images using the 3D workstation software. ROIs were placed and framed on the CT image subjectively showing the greatest area of stomach contents. Thus, ROI sizes and locations were based on imaging findings on a case-by-case basis and were not kept constant among the cases. In Group 1, we also outlined the most well-defined basal layer with the highest X-ray absorption and measured the average CT number within this layer.

## Results

The detailed characteristics of the 23 cases are shown in Tables 1 and 2. There are 14 cases in Group 1 (Case 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 18, 21, and 22), 6 cases in Group 2 (Case 1, 2, 3, 8, 19, and 20), and 3 cases in Group 3 (Case 5, 17, and 23). Twenty cases (87%) showed high X-ray absorption: 14 and 6 of these cases belonged to Groups 1 and 2, respectively. Among the 23 cases, masses of food such as rice, seaweed, meat, or vegetables were found in 8 cases: two in Group 1 (Case 16 and 21), five in Group 2 (Case 1, 2, 3, 8, and 19), and one in Group 3 (Case 23).

In all 23 cases, the highest and lowest mean CT numbers were 127 HU (Case 7) and 11 HU (Case 23), respectively. In Group 1, the mean, maximum, and minimum values of the evaluated layer were 149 HU, 354 HU (Case 18), and 74 HU (Case 6), respectively. The averaged maximum, mean, and minimum CT numbers in each group, shown in Table 3, suggest the presence of objective differences between groups in terms of visibility within gastric contents.

There were three cases in Group 3 (no high X-ray absorbed materials observed). In Case 5, the patient complained of poor physical condition on the day before his death. The next morning, he was found dead on his bed and his clothes were covered with vomitus. A drug screen detected sulpiride, zolpidem, imipramine, trazodone, and amobarbital. Autopsy revealed 35 ml of fluid in the stomach. In this case, only amobarbital was analyzed quantitatively according to the pathologist's instruction. In Case 17, the body was immersed in water at a riverside; however, his face was out of the water. There were 120 empty packages of psychotropic drugs around the death scene. The water temperature was 3°C. Autopsy revealed 30 ml of fluid in the stomach. The blood in the left atrial cavity was not bright red. The left and right lungs weighed 370 and 410 g, respectively. The cut surface of the lungs was dark red and did not exhibit drying or severe edema. The airway was empty. In Case 23, the patient was sleeping when her husband came home. After he woke her, she said that she wanted to go to the toilet. As he took her there, she collapsed suddenly. There were 21 empty packages of prescription drugs in the kitchen. Autopsy revealed 440 g of muddy-appearing content with a mushroom and carrot in the stomach.

In 14 cases in which we obtained plain X-ray images (including 10 cases in Group 1; 2 cases in Group 2; and 2 cases in Group 3), no materials with high X-ray absorption were detected on chest and/or abdominal X-ray images. For example, in Case 18, high X-ray absorbed sedimentation in the stomach was identified by postmortem abdominal CT (Fig. 4a) but not by plain chest radiograph (Fig. 4b).

## Discussion

On postmortem CT examination, drugs were fre-

Table 2. Autopsy and CT findings of stomach contents.

| No. of case | Autopsy findings of stomach contents | | | | | CT findings of stomach contents | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Estimated postmortem interval | Volume (mL) | Solid contents | | Fluid | Group of stomach contents* | Area of stomach contents[#] ( $cm^2$) | CT numbers on stomach contents | | | |
| | | | Drug Tablets | Others | | | | Mean (HU) | Max (HU) | Min (HU) | Average of basal layer[##] (HU) |
| 1 | several weeks (some decomposition) | 420 | - | Rice, meat, and *udon* (Japanese wheat-based noodle) | | 2 | 64 | 51 | 113 | -166 | |
| 2 | 2 days | 90 | + | Rice and seaweed | | 2 | 48 | 28 | 88 | -61 | |
| 3 | a few days | 400 | - | Rice, vegetables, and *shinachiku* (fermented bamboo shoots) | | 2 | 95 | 29 | 99 | -285 | |
| 4 | a few days | 500 | + | | Brown fluid | 1 | 66 | 57 | 598 | -158 | 174 |
| 5 | a day | 35 | - | | Non-viscous fluid | 3 | 34 | 19 | 79 | -117 | |
| 6 | several days | 115 | + | | Brown fluid | 1 | 40 | 34 | 117 | -430 | 74 |
| 7 | a day | 30 | + | | Red fluid | 1 | 5 | 126 | 240 | -48 | 165 |
| 8 | a few days | 260 | - | Rice | | 2 | 33 | 47 | 143 | -713 | |
| 9 | Not available | | | | | 1 | 25 | 38 | 273 | -285 | 149 |
| 10 | 2 days | | + | | Non-viscous fluid | 1 | 25 | 115 | 284 | -58 | 149 |
| 11 | a few days | | + | | | 1 | 46 | 22 | 208 | -68 | 175 |
| 12 | a few days | 70 | + | | Non-viscous fluid | 1 | 19 | 31 | 119 | -11 | 81 |
| 13 | a few days | 100 | + | Muddy contents | | 1 | 35 | 46 | 187 | -92 | 123 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | a few days | 70 | + | | Viscous fluid | 1 | 22 | 41 | 140 | -31 | 86 |
| 15 | a few days | 25 | + | | Viscous fluid | 1 | 9 | 24 | 198 | -28 | 123 |
| 16 | a few days | 500 | + | Rice, pieces of eggs | | 1 | 58 | 59 | 117 | -34 | 140 |
| 17 | a day | 30 | - | | Brown fluid | 3 | 16 | 16 | 69 | -37 | |
| 18 | a few days | 100 | + | | | 1 | 27 | 73 | 844 | -106 | 384 |
| 19 | a few days | 100 | - | Carrots, Chinese cabbage, and *shinachiku* (fermented bamboo shoots) | | 2 | 12 | 24 | 89 | -413 | |
| 20 | a day | 80 | - | Muddy contents | | 2 | 23 | 22 | 67 | -425 | |
| 21 | a few days | 290 | + | Rice, pieces of vegetables | | 1 | 59 | 4 | 199 | -816 | 141 |
| 22 | a few days | 250 | + | | Brown fluid | 1 | 46 | 20 | 254 | -87 | 122 |
| 23 | a few days | 440 | - | Carrots, mushrooms | | 3 | 42 | 11 | 85 | -48 | |

++ : well-defined high X-ray absorption materials. + : ill-defined high X-ray absorption materials. −: no high X-ray absorption materials.
*Group of stomach contents: See text.
#Area of stomach contents: The area within the region of interest (ROI) where CT numbers of stomach contents were measured.
##Average of basal layer: The average CT number within the basal layer of high X-ray absorption contents in Group 1 cases.
CT, computed tomography; HU, Hounsfield units.

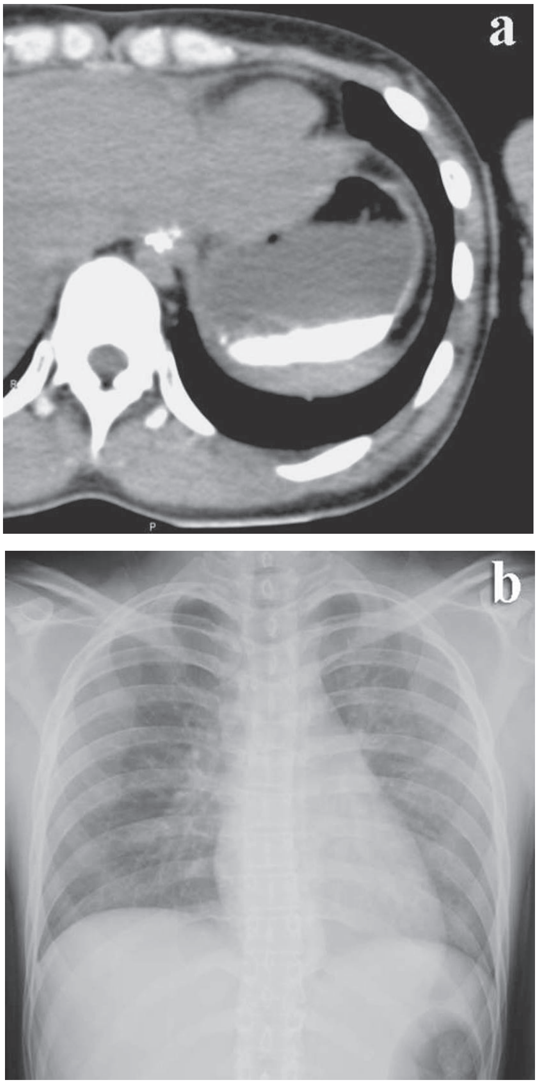


Fig. 4. Postmortem radiological images of Case 18 (Group 1).
(a) Abdominal axial CT image at the level of the 11th thoracic vertebra shows high X-ray absorbed content in the stomach.
(b) The gastric content was not found on plain chest X-ray.

quently visualized as stomach contents with high X-ray absorption. In the present study, 20 of 23 (87%) cases with intoxication as the cause of death showed high X-ray absorption, while images in the remaining three cases were not radio-dense. From a radiological point of view, death by intoxication was diagnosed in this series with high probability. On the other hand, from a forensic point of view, postmortem CT imaging alone contributes minimally to the final diagnosis, and thus its use in this context raises issues of cost and potentially misleading findings.

The mean CT number in stomach contents among all 14 cases in Group 1 was 149 HU, which was similar to the value of 146 HU reported by Burke et al. (2012), who also evaluated CT images of stomach contents in cases of drug overdose. In all cases in Group 1, measurements showed a high maximum CT number, as shown in Tables 2 and 3.

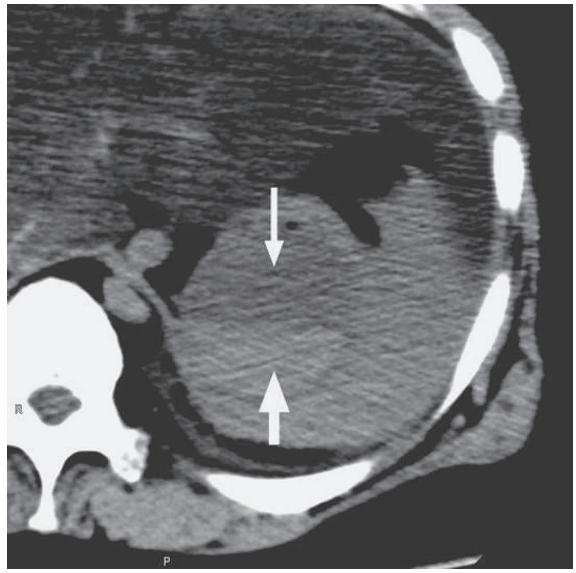

Fig. 5. Postmortem abdominal CT image of Case 20.
The CT image shows different gray levels of the double-layered gastric contents. The upper layer (arrow) has lower X-ray absorption than the lower layer (thick arrow).

The average value was approximately 270 HU. In simple terms, each well-defined drug mass was visualized in the stomach as an area with high X-ray absorption, suggesting the possibility of fatal intoxication. However, in cases in Group 3, CT showed no material with high X-ray absorption.

In some cases in Group 1, materials with high X-ray absorption occupied one-third to one-half of the stomach contents; in other cases, however, such contents were seen in only a small layer. Additionally, six cases in Group 2 showed an ill-defined border, although the blood drug concentration indicated a toxic or lethal dose. Because the amounts and types of drugs ingested, the gastric digestion rate, and the drug metabolism rate vary among individuals, it is impossible to evaluate the relationship between CT images and the blood concentrations of drugs. Therefore, the use of CT images to diagnose death by drug overdose is associated with several problems and limitations.

Like drugs, many foods show high X-ray absorption. Usui et al. (2016) reported that the CT number of mochi rice cake was 134 HU. In this study, the CT values of seven cases (Case 6, 12, 13, 14, 15, 16, and 22) with a well-defined basal layer were similar to or lower than that of mochi. Additionally, in our previous experience, some food residues such as rice, noodles, seaweed, or seeds also have high X-ray absorption. In the present study, eight of 23 cases (Case 1, 2, 3, 8, 16, 19, 21, and 23) contained food materials at autopsy. However, Case 23 was in Group 3 and showed low radiopacity. In our cases, foods did not always show high X-ray absorption. It is difficult to differentiate drug masses from some types of foods when only radio-dense images are used. The dispersion state of mate-

Table 3. Differences in gastric content CT numbers between groups.

| | Average CT number [HU] | | |
|---|---|---|---|
| | Max. | Mean | Min. |
| Group 1 (n = 14) | 270 | 149 | -161 |
| Group 2 (n = 6) | 100 | 35 | -343 |
| Group 3 (n = 3) | 77 | 15 | -67 |

CT, computed tomography; HU, Hounsfield units.

rials with high X-ray absorption affects the visibility of gastric contents. In Case 8, classified as Group 2, the maximum CT number of the stomach contents was high at 143 HU, and the contents included a large amount of rice (weight 260 g). The contents with high X-ray absorption were spread out in the stomach cavity without a well-defined basal layer. Visibility also depends on how much food is also in the stomach. In Case 20, classified as Group 2, the maximum CT number of the stomach contents was 67 HU, no greater than that of Group 3 (79 HU [Case 5], 69 HU [Case 17], and 85 HU [Case 23]). However, this content clearly formed a double-layered structure: the average CT number of the upper layer was 19 HU and that of the lower layer was 35 HU. Thus, the lower layer contained relatively high X-ray absorption materials (Fig. 5).

In Group 3, three cases showed no material with high X-ray absorption, although drug analysis detected a lethal concentration of the drugs in the blood. This radiological finding (no high X-ray absorption materials in stomach) can lead to misinterpretation. Two cases (Case 5 and 17) showed only fluids, and the other case (Case 23) showed muddy-appearing contents, including a large amount of food. In Case 5, vomitus was found near the face, and a large volume of stomach contents, including drugs, might have been vomited in the agonal stage. In Case 17, the detected drugs were flunitrazepam, sulpiride, mirtazapine, and brotizolam. In Case 23, the detected drugs were olanzapine, quetiapine, and fluvoxamine. Savitt et al. (1987) reported that many pills did not show high radiopacity, and the drugs in Cases 17 and 23 had low radiopacity. In these two cases, many empty drug packages were found at the scene of death, which presumably suggested the possibility of intoxication.

Diagnosing drug overdose via CT scan is also hampered by instrumental limitations, as intra- and inter-scanner variability is always present when determining CT attenuation values (Birnbaum et al. 2007). CT numbers vary among MSCT scanners and with individual combinations of scanner and reconstruction kernels (Birnbaum et al. 2007). The tube potential (in kV) particularly affects attenuation measurements. In this study, MSCT scanning was performed at a constant voltage of 120 kV and images were reconstructed with the kernel for soft tissue. CT numbers may also be affected by other variables such as artifacts, beam hardening, object orientation, and size (Hunter et al. 1983). Technical parameters within the optimal range must be used to ensure reliable CT number measurement when estimating gastric contents (Birnbaum et al. 2007).

In this study, plain radiographs did not detect X-ray absorbed materials in the stomachs of individuals with established oral intoxication, suggesting that plain X-ray images have a questionable role in such cases (see Fig. 4). Because CT has excellent contrast resolution, it can be used to discriminate between materials with different densities and visualize radio-dense gastric contents in cases where this is not possible with plain X-ray images.

In summary, if there are empty drug packages or a suicide note at the death scene, stomach contents with high X-ray absorption suggest drug overdose as the cause of death. However, in some cases of death due to intoxication, the stomach contents do not have high X-ray absorption, and conversely, many foods do show high X-ray absorption. Postmortem gastric CT images can provide useful information in cases of oral drug intoxication, but precise determination of the cause of death requires full autopsy in cases where there is no indication of suicide at the death scene.

## Conflict of Interest

The authors declare no conflict of interest.

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