

## Deaths in Bathtubs in Japan: Forensic and Clinical Implications

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In Japan, deaths in bathtubs or *bathtub deaths* are frequently investigated as unnatural deaths. About 19,000 bathtub deaths occur annually in Japan. This pattern of death has become a social issue in forensic pathology and emergency medicine and public health. It is assumed that the death of an adult by drowning in a bathtub cannot be avoided due to disturbance of consciousness. The PubMed database was used for literature search using the retrieval words, “bathing “OR” bathtub “AND” submersion “OR” drowning “OR” death “OR” cardiopulmonary arrest”. From the epidemiological characteristics and pathophysiological findings of bath mortality in Japan, three etiologies of impaired consciousness have been proposed: acute ischemic heart failure, heatstroke, and blood pressure fluctuation. Moreover, other causes such as epilepsy and alcohol or drug intake cannot be ignored as potential risks for death in a bathtub. It is also important to note the possibility of suicide and, although extremely rare, homicide in a bathtub. Despite research, the exact causal relationship between bathtub bathing and death remains unclear. Further, the cause of death by postmortem investigation is not always easily determined. Hence, it is desirable to carry out a field survey of causes of death, including bathing conditions, and, wherever possible, a complete autopsy survey. An exclusion of critical cases such as crime-related death, suicide, drug poisoning, and carbon monoxide poisoning is optimal. Of the many hypotheses about the causes of bathtub mortality, the most consistent hypothesis will be medically inferred from the death history, case findings, and test results. (J Nippon Med Sch 2022; 89: 33–39)

**Key words:** death, bathtub, cardiopulmonary arrest, heat illness

### Introduction

Postmortem investigations of unnatural deaths in bathtubs—or *bathtub deaths*—are frequently conducted in Japanese forensic practices as the mortality rate of older individuals due to accidental drowning in a bathtub is extremely high, even by global comparison<sup>1</sup>. This could be because 60%-80% of Japanese people bathe in a bathtub<sup>2</sup>, and the Japanese lifestyle<sup>3</sup> includes a daily hot bath by submerging the body to shoulder level.

Therefore, there is a need for careful postmortem investigations into these deaths from various perspectives such as cause-of-death statistics, life insurance, and criminal investigations. Studies<sup>4-8</sup> on bathtub deaths have been conducted widely within forensic medicine. Unfortunately, the diversity in the mechanisms of bathtub deaths makes it challenging to determine the cause of death.

This review aimed to gain an understanding of the in-

terests and goals of researchers investigating bathtub deaths in Japan by outlining the characteristics of bathtub deaths, discussing the mechanisms of bathtub death that have been elucidated hitherto, and explaining the main points of postmortem investigations in such deaths.

### Definition of Bathtub Death and Literature Search

To achieve the purpose of this review and differentiate bath-related deaths outside the bathtub, a case of death or cardiopulmonary arrest during bathtub bathing was defined as “bathtub death” in this study.

The PubMed database was used for literature search. The literature was narrowed down using English and Japanese filters published in medical journals and retrieval words, “bathing” OR “bathtub” AND “submersion” OR “drowning” OR “death” OR “cardiopulmonary arrest”. Reports from Japan discussed bathtub death of

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Table 1 Categories and possible etiologies of deaths in bathtub

	Internal cause of death	External cause of death
Drowning	Epileptic disease Cerebrovascular disease Altered consciousness due to blood pressure changes	Intoxication due to alcohol Heat illness Electric shock Pure accidental drowning
Not drowning	<i>Sudden cardiac death</i> Lethal arrhythmia	Carbon monoxide poisoning Acute ethanol poisoning Suicide Criminal death

This classification is not definitive. For example, if the deceased loses consciousness due to cerebrovascular disease and his/her face does not immersed, the deceased could die of illness without drowning. Furthermore, there are cases in which drowning can be unidentified or undetermined even by a thorough autopsy.

older adults from the perspective of illness, while reports from other countries discussed bathtub death from the perspective of the abandonment of murder, child abuse, adolescent patients with epilepsy, and suicidal drowning after taking hypnotic drugs. The literature was further screened according to the actual situation in Japan, and includes the important risk factors of "bathtub death".

### Epidemiology

Death certification or vital statistics by mortality in Japan makes it difficult to accurately tabulate the actual situation of nationwide bathtub deaths in Japan. Under these restrictive circumstances, various researchers have attempted fact-finding investigations.

Matsui et al.<sup>9</sup> reported on the trends in the number of people and mortality rates (per 100,000 population) associated with accidental drowning between the years 1980 and 2005. The number of accidental drownings increased significantly from 1995, and has been increasing to a slight plateau of about 6,000 per year since then. Only 60% of these cases have been classified as "in the bathtub," and 85% of the "drowning in the bathtub" cases (3,471 people) have been in older adults. Naturally, since not all bathtub deaths were classified as accidental drownings, the total number of bathtub deaths in Japan is thought to be several times larger than that reported.

Suzuki et al. surveyed the emergency medical system data for deaths registered as bath-related in 2012 and estimated that the total number of deaths in the six winter months (October to April) was 13,369 (95% CI, 10,862 to 16,887), and the total number of annual bath-related deaths was 18,775 (95% CI, 15,207 to 23,642)<sup>10</sup>. This data suggests that around 1.5 of every 100 Japanese people die or experience a cardiopulmonary arrest in a bathtub.

It has been noted that ambient outdoor temperature<sup>8,11-13</sup> is significantly correlated with the incidence of bath-related, including bathtub deaths. Considering sudden deaths of older people in bathtubs, several epidemiological characteristics have been elucidated<sup>8</sup>. Specifically, in the 23 wards of Tokyo, the incidence of bathtub death in men was higher than that in women. The incidence rate increased sharply with aging and by a factor of 1.092 with every 1°C decrease in the average temperature on the bathing day.

In terms of the cause of death, Kanawaku et al.<sup>8</sup> in 2015 analyzed 999 sudden bathtub deaths of the 1,408 bath-related deaths in the 23 wards of Tokyo. Only 6.18% (87/1,408) of the deaths occurred in the washing or changing areas. Reportedly, 73.2% of sudden deaths in older adults in bathtubs are due to ischemic heart disease.

### The Mechanism of Altered Consciousness in the Bathtub

The hypothesis that drowning in a bathtub is preceded by altered consciousness due to factors such as illness and alcohol has been mentioned<sup>14</sup>. Although this hypothesis should also be considered for the deceased recovered from seas and rivers, it should be strongly considered in bathtub deaths.

When considering this hypothesis and classifying bathtub deaths, it is necessary to determine the cause of altered consciousness while in the bathtub, and establish whether water was aspirated while drowning before death (Table 1).

#### Cardiovascular Disease

In many cases, forensic diagnosis of bathtub deaths identifies the cause of death as heart disease, such as

acute ischemic heart failure<sup>8,15</sup>. Bathtub deaths are considered a form of sudden death due to tachyarrhythmic conditions, such as ventricular fibrillation, similar to unnatural deaths outside the bathtub. Hence, such deaths are abrupt, and even if there is agonal respiration, it is for a short time only. Therefore, if acute ischemic heart failure is presumed as the cause of death in a bathtub, it would be controversial to argue that water aspiration during drowning is the direct cause of death.

In addition, since many bathtub deaths involve older adults, autopsies often reveal coronary arteriosclerosis. Further studies are needed to determine whether the underlying condition of acute ischemic heart failure causes altered consciousness in the bathtub or it is merely a confounding factor.

#### **Cerebrovascular Disease**

The statistics report of the 23 wards in Tokyo mentions cases of cerebrovascular diseases revealed during post-mortem investigations of sudden bathtub deaths; however, these account for only a small share of the cases. Inamura examined the incidence of subarachnoid hemorrhage, cerebral hemorrhage, and cerebral infarction in bath-related deaths and showed little involvement of stroke as the cause of bathtubs death since the majority of bath-related stroke patients had collapsed outside the bathtub<sup>16</sup>.

#### **Altered Consciousness Due to Blood Pressure Changes (Hypotension)**

Blood pressure may fluctuate during the bathing process. Sympathetic activity increases when moving from a cold changing area to a hot bathing area, and vasodilation accompanies the rise in body temperature, reducing blood pressure. The pathophysiological hypothesis is that hypotension resulting from such blood pressure fluctuations causes altered consciousness, leading to drowning.

Although there are reports on the impact of bathing in bathtubs on blood pressure regulation in older adults<sup>17,18</sup>, these have been limited to healthy people, and it is difficult to confirm bathing as the cause of bathtub deaths in such cases.

#### **Epileptic Disease**

Epileptic diseases are known risk factors for bathtub death<sup>19-25</sup>. Sudden deaths in epileptic patients do occur, explained by the disease concept *sudden unexpected death in epilepsy*<sup>26</sup>. Bathtub deaths in such cases are considered as being due to arrhythmia or respiratory failure occurring at the time of bathing.

#### **Heat Illness**

Heat illness is a hypothesis advocated in emergency

medicine whereby prolonged immersion in hot water causes a rise in body temperature, subsequently leading to altered consciousness. This hypothesis is supported by investigations showing that many patients who develop altered consciousness, after transport to the hospital, show no abnormalities on echocardiograms or head computed tomography (CT). The altered consciousness improves once the body temperature normalizes<sup>27</sup>.

This hypothesis seems valid for people who survive after suffering altered consciousness in a bathtub, regardless of whether water was aspirated during drowning. However, it is controversial whether many bathtub deaths seen in forensic medicine can be explained by heat illness.

#### **Miscellaneous**

Although various other medical issues (disease<sup>28-31</sup> and electric shock<sup>32,33</sup>) have been mentioned, the following three are particularly important:

##### **Alcohol**

Blood alcohol is often observed in cases of death in a bathtub<sup>4,34</sup>. Alcohol is a main cause of drowning in a bathtub, and also increases the risk of diseases that cause altered consciousness. The former is explained by the impact of alcohol on the central nervous system, inducing somnolence and causing altered consciousness, leading to drowning while bathing. People also fall due to poor balance after consumption of alcohol. This is due to the various pharmacological effects of alcohol<sup>35,36</sup>, acting synergistically with the impact of bathing itself, leading to conditions such as cardio/cerebrovascular diseases and arrhythmia.

##### **Carbon Monoxide Poisoning**

Acute carbon monoxide poisoning may occur during bathing when a water heater is installed in the bathroom and incomplete combustion occurs due to device malfunction<sup>37</sup>. Carbon monoxide-hemoglobin saturation need not be high to cause altered consciousness and death for someone in a bathtub.

##### **Drug Poisoning**

Multiple studies on bathtub death have reported that drugs were detected in the deceased individual's blood<sup>38-42</sup>. In these situations, the possibility that altered consciousness was due to drug effects must be considered. Suicide by drowning after an overdose of drugs/medication<sup>43</sup> is also a possibility.

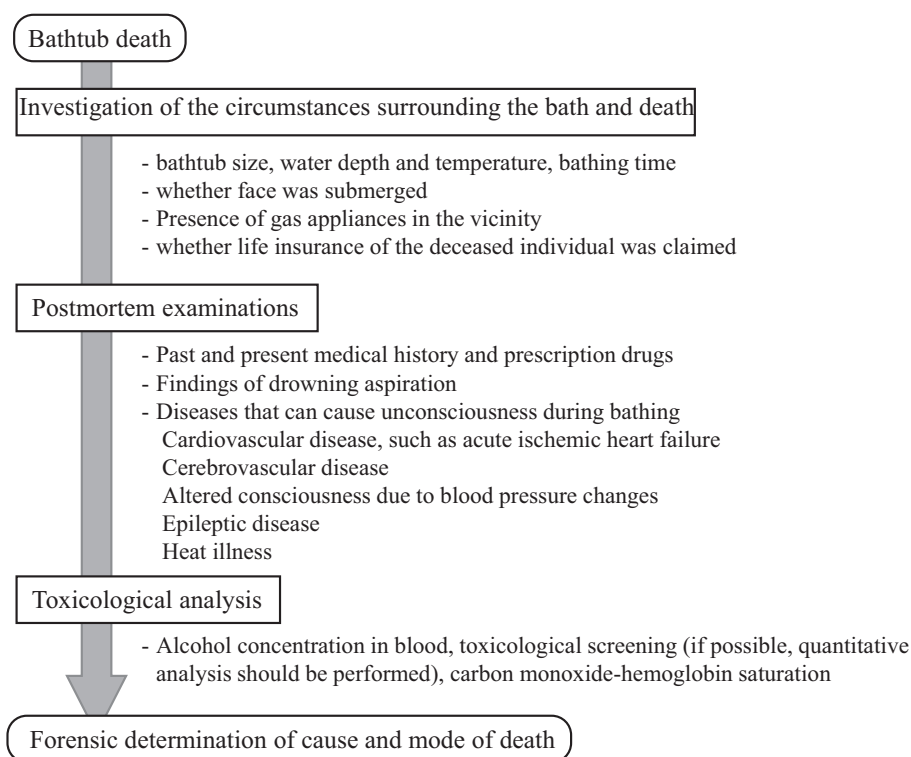


Fig. 1 Forensic diagnostic flow diagram of bathtub death

### Postmortem Investigation (Fig. 1)

#### Investigation of the Circumstances Surrounding a Bath and Death

For all bathtub deaths, it is necessary for the police to ascertain the conditions of the changing and bathing rooms (including the bathtub size), water depth and temperature, bathing time, placement of electrical appliances and switches, whether the face of the deceased was immersed in water, and frequency of monitoring the deceased by co-habiting family members. It is recommended that the gas company inspect the gas appliances and determine whether incomplete combustion can be ruled out.

#### Findings of Postmortem Examination and Autopsy

The general pathological findings should be appropriately determined. If a disease is severe enough to cause altered consciousness, it is enough to cause death in a bathtub; however, such pathological findings tend to be subtle. A thorough autopsy is needed to determine the exact cause of death.

Furthermore, it is essential to determine whether the deceased aspirated water while drowning. Typical aspiration findings include white or hemorrhagic edema fluid in the nasal passage, mouth, and airways; pulmonary edema; and hyperinflated lungs occupying the pleural cavity; white or hemorrhagic foam in the trachea and

bronchi; and water in the entire gastric cavity. The spectrum<sup>44</sup> of changes in the lungs ranges from absence of wetness and edema to heavily edematous lungs in cases of drowning in natural waters such as seas and rivers. However, aspiration must not be ruled out based entirely on these autopsy findings.

In contrast to patients who are urgently transported to hospitals, high temperature in corpses found in bathtubs is not definitive proof of heat illness because the body temperature rises with continued immersion in hot water, regardless of the cause of death.

#### Toxicological Analysis

Measurement of blood alcohol, routine toxicological screening, and quantification of carbon monoxide-hemoglobin saturation should be performed in all cases wherever possible.

#### Forensic Determination of the Cause and Mode of Death

To determine the cause of bathtub deaths, complete necropsy including a thorough toxicological analysis must be performed, along with an investigation of the circumstances surrounding the bath and death. Further, toxicological analyses should be conducted promptly to rule out the involvement of alcohol, carbon monoxide, and drugs.

In addition, the age, sex, medical history, and autopsy findings of the deceased should be analyzed to identify lesions and injuries that can result in altered consciousness leading to bathtub death, or to assess for underlying risk factors for the development of such lesions. As multiple hypotheses have been proposed for the mechanism of bathtub deaths, the cause of death should be refined in each case based on the most medically consistent hypothesis.

Sato et al. noted that forensic pathologists tend to determine that a bathtub death is natural due to sudden cardiac death when evidence is insufficient to suggest drowning and water aspiration<sup>6</sup>. Sudden cardiac death is a reasonable judgment because it is presumed that the affected person will die rapidly due to a fatal arrhythmia. However, as mentioned earlier, it is necessary to interpret drowning and aspiration based on aspiration findings carefully.

Based on studies of suicide, bathtub suicide cases require careful investigation to distinguish them from accidents. Doctors involved in postmortem investigations should always exclude the rarely encountered crime-related bathtub deaths<sup>45</sup>.

If a thorough investigation does not reveal the cause of death, it should be indicated as undetermined or unspecified drowning.

### Insurance

A contract system in Japan increases life insurance benefits if the death is not due to illness but due to accidental extrinsic injury. As the cause of death being accidental and extrinsic is important in this case<sup>46</sup>, deaths in bathtubs are prone to insurance controversies. For life insurance companies, intoxication during bathing is a point of significant concern while conducting life insurance audits.

### Conclusion

Although some robust hypotheses have been proposed for the pathophysiology and causes of deaths in bathtubs, it has not been entirely elucidated yet. It is desirable to gather comprehensive information about the environment, bathing conditions, and medical findings such as autopsy results and CT images, to identify the most valid explanation for the cause of death. It is also essential not to overlook the sporadic cases of homicide disguised as drug or carbon monoxide poisoning and confuse them with the more common bathtub deaths.

The limitation of this review is its primary reference to

the forensic pathology literature. Therefore, there may be a bias in the literature collected. Accurate assessment of the mechanism of bathtub death must integrate both forensic and clinical literature.

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