

Bath-related deaths: Preventive strategies and suggestions for general physicians

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Abstract

Bath-related deaths occur frequently in Japan, particularly in the elderly population; however, this fact is not sufficiently well known by the public. The advent of a super-aging society will expose general physicians to more cases of fatal and nonfatal bath-related accidents. As many of the victims have one or more lifestyle-related diseases, general physicians will play a more important role in preventing these fatalities in the future. In addition, general physicians may have to perform postmortem examinations in these cases. This review article addresses the latest studies on bath-related deaths from various medical departments, including forensic medicine, emergency medicine, and physiology. We also discuss preventive strategies based on the assumed mechanisms, and because Japan does not have a well-developed system of medical examiners, we also provide suggestions for physicians who will encounter bath-related deaths in the future.

KEYWORDS

bath-related death, epidemiology, mechanism of death, prevention

1 | INTRODUCTION

Although cultural practices related to baths vary across countries, baths are considered a mode of relaxation by many people across the world. Unfortunately, many cases of sudden deaths during bathing have been reported to date.¹⁻¹³ In most cases, death occurs in a bathtub, and victims are found unresponsive with their faces immersed or completely submerged under the water. These deaths are a critical social issue, especially in Japan, where approximately 19 000 sudden bath-related deaths occur annually nationwide.¹⁴

The Japanese bathing style is characterized by immersion in hot water at temperatures above 41°C.¹⁵ Japanese bathtubs are generally deeper than the bathtubs in other countries, and people sit in hot water up to the shoulder level. They also like to take long baths. This style of bathing may be associated with bath-related deaths, but the precise mechanism underlying this relationship has not been fully understood. In this review, we address the latest studies on bath-related

deaths from various medical departments, including emergency medicine, forensic medicine, and physiology, focusing especially on the mechanism of death. In addition, we also assess preventive strategies based on the assumed mechanism of death, and considering the fact that Japan does not have a well-developed system of medical examiners, we provide suggestions for general physicians who will perform more postmortem examinations of bath-related victims in the near future.

2 | EPIDEMIOLOGY OF BATH-RELATED DEATHS

Most bath-related deaths occur among individuals older than 60 years,⁴⁻⁶ and the mortality rates tend to increase with age in both sexes (Figure 1).⁵ There is an evident seasonal difference in occurrence dates,^{4,5} with the deaths occurring 6.9 times more frequently in winter

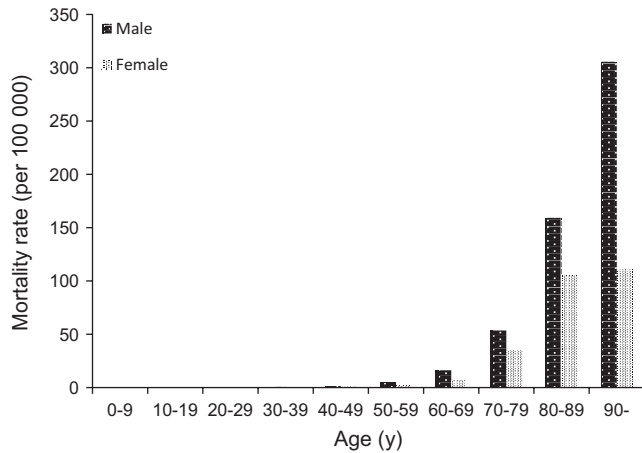


FIGURE 1 Age-specific mortality rates of bath-related deaths (cited from ref. 5)

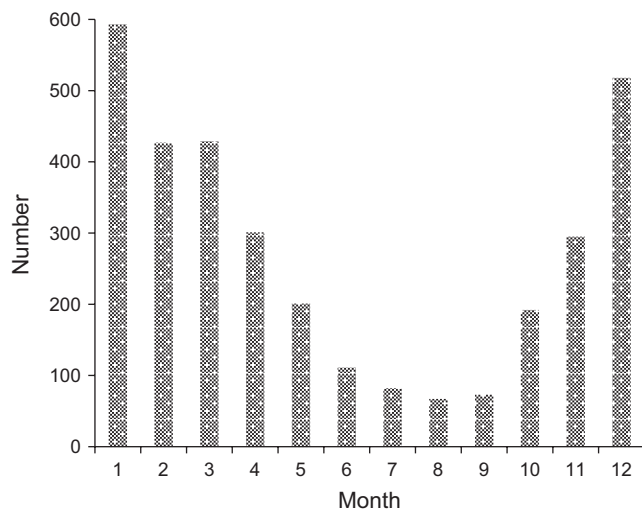


FIGURE 2 Number of bath-related deaths according to month (adapted from ref. 5)

than in the summer (Figure 2).⁵ Concurrently, lower air temperatures are closely associated with higher rates of bathing-related deaths.¹⁶ The monthly numbers of such deaths significantly and negatively correlated with air temperature and humidity (mean air temperature). A single regression line showed that a decrease of 1°C in the mean air temperature corresponded to a monthly increase of 0.095 deaths per 100 000 persons.¹⁶

The overwhelming majority of bath-related deaths occurred in the deceased's own residence (Table 1).^{4,5} Representative past medical histories of bath-related victims in Tokyo Metropolis in 2009 (N=1001) are shown in Table 2. Hypertension was the most common medical complaint among the victims. Bath-related deaths can be attributed to various causes, including natural death (disease), accidental drowning, and suicidal death.^{4,8} In general, most of the cases are judged as natural deaths or accidental drowning, and suicidal or homicidal cases are rare. Satoh et al. reviewed 268 victims of bath-related deaths and reported that the manner of death was judged as natural death in 191 cases (71%) and accidental drowning in 63 (23%).⁴

TABLE 1 Settings of bath-related deaths (n=3289). (Cited from ref. 5)

Home	3102	(94.3%)
Communal bath	100	(3.0%)
Hotel	52	(1.6%)
Nursing home and hospital	27	(0.8%)
Others	8	(0.2%)

TABLE 2 Past medical histories of bath-related victims (N=1001)

Disease	Number
Hypertension	395
Diabetes mellitus	181
Cancer	135
Ischemic heart disease	121
Old cerebral infarction	104
Hyperlipidemia	95
Dementia	94
Atrial fibrillation	55
Parkinson disease	39

3 | RESEARCH REGARDING THE MECHANISMS UNDERLYING BATH-RELATED DEATHS

3.1 | Autopsy studies on bath-related deaths

There are several studies investigating the autopsy findings for bath-related deaths.⁴⁻⁷ Suzuki et al. analyzed 550 autopsied cases of bath-related deaths in Tokyo Metropolis and found that water inhalation signs were observed in many cases (n=435, 79.1%) (Table 3).⁵ Among the major autopsy findings, circulatory system diseases constituted more than half of the pathological findings that could have contributed significantly to death (n=300, 54.5%), and cardiac lesions (eg, coronary artery stenosis, cardiomegaly) were the most common pathological findings (n=250, 45.5%). However, approximately one-third of the cases exhibited no remarkable pathological findings, including 13 cases involving epilepsy and eight involving psychotropic drug poisoning (n=198, 36.0%). A quarter of all cases involved blood ethanol levels that exceeded 0.5 mg/mL (n=140).⁵

Satoh et al. analyzed 173 cases of bath-related deaths autopsied at Tokai University School of Medicine, Kanagawa prefecture,⁴ and reported that drowning water aspiration was confirmed in 72% of the victims (n=124), and the most common observations were heart disorders, such as cardiac ischemic changes and cardiomegaly (n=87, 50.3%), especially in people older than 70 years. Among external factors, high levels of ethanol (1.0 mg/mL or greater) and drug over-dosage involving antipsychotics were detected in 32 cases (18.5%).

Okuda et al. performed a retrospective review of 92 bath-related deaths in the state of Maryland.⁷ They reported that drowning was confirmed in 71.7% of the cases, and the three leading contributing

TABLE 3 Major autopsy findings according to drowning sign (Adapted from ref. 5)

	Total cases (n=550)	Drowning sign (+) (n=435)	Drowning sign (-) (n=115)
Circulatory disease	300 (54.5%)	234 (53.8%)	66 (57.4%)
Coronary artery stenosis and/or cardiomegaly	239 (43.5%)	188 (43.2%)	51 (44.3%)
Other heart disease (ie, valvular disease)	11 (2.0%)	5 (1.1%)	6 (5.2%)
Cerebral artery sclerosis and/or cerebral infarction	29 (5.3%)	29 (6.7%)	0
Cerebral hemorrhage	15 (2.7%)	9 (2.1%)	6 (5.2%)
Other circulatory disease	6 (1.1%)	3 (0.7%)	3 (2.6%)
Noncirculatory system disease	47 (8.5%)	28 (6.4%)	19 (16.5%)
Respiratory disease	13 (2.4%)	6 (1.4%)	7 (6.1%)
Digestive disease	4 (0.7%)	1 (0.2%)	3 (2.6%)
Neoplasms	13 (2.4%)	8 (1.8%)	5 (4.3%)
Endocrine, nutritional, and metabolic diseases	7 (1.3%)	5 (1.1%)	2 (1.7%)
Nervous disease	5 (0.9%)	5 (1.1%)	0
Genitourinary system	5 (0.9%)	3 (0.7%)	2 (1.7%)
Trauma	5 (0.9%)	4 (0.9%)	1 (0.9%)
No pathological findings	198 (36.0%)	169 (38.9%)	29 (25.2%)
History of epilepsy	13 (2.4%)	12 (2.8%)	1 (0.9%)
Psychotropic drug poisoning	8 (1.5%)	7 (1.6%)	1 (0.9%)
Others	177 (32.2%)	150 (34.5%)	27 (23.5%)
Blood ethanol level exceeded 0.5 mg/mL	140 (25.5%)	121 (27.8%)	19 (16.5%)
Mean blood ethanol level (mg/mL)	0.44	0.48	0.28

Percentages indicate the proportion of each finding to the total number of cases in each group.

causes of death were cardiovascular disease, drug/alcohol-related death, and seizure disorder.

3.2 | Studies of patients who became sick without cardiopulmonary arrest during baths

A study investigated patients who became sick during bathing and were transported to emergency hospitals without showing cardiopulmonary arrest.¹⁷ Among the vital signs recorded by the rescue squad crew, consciousness disturbance was observed in more than 70% of the patients; however, most of them showed mild disturbance. Hyperthermia ($\geq 38^{\circ}\text{C}$) was observed in about 30% of the patients. In addition, 56% of the patients showed tachycardia ($>100/\text{min}$). According to the available medical records ($n=756$), the most common diagnosis was transient consciousness disturbances (30.6%), followed by dehydration (20.4%) and syncope (9.4%). Cerebral hemorrhage (4.0%) and cardiac diseases (eg, acute myocardial infarction) (0.7%) formed a minority, and around half of the cases were considered to be mild without the need for hospitalization.

3.3 | Physiological studies

3.3.1 | Changes in hemodynamic parameters

Several physiological studies demonstrated significant changes in hemodynamic parameters during bathing among elderly people.^{3,18} An increase in the double product (systolic blood pressure \times heart

rate), which reflects myocardial oxygen consumption, was observed in elderly people immediately upon immersion, while it remained constant in young people.¹⁸ However, about 4 minutes after bathing in a bathtub, blood pressure and heart rate subsequently decrease in the elderly.¹⁸ With regard to heart rate variability, the high-frequency component, which has been used to infer parasympathetic nervous activity, decreased in young subjects, but not in the elderly.¹⁸ This result suggests that hypotensive syncope caused by drowning during hot bath immersion is one cause of sudden death among elderly persons, and is a consequence of the decrease in sympathetic tone that develops approximately 4 minutes after immersion.

Another study showed that a significant decrease in systolic blood pressure in elderly persons was observed not only after 4-5 minutes of bathing, but also after getting out of the water.¹⁹ Among 48 cases in which a decrease in systolic blood pressure was observed after the subjects got out of the water, 39 showed a systolic blood pressure reduction of less than 30 mm Hg. The maximum decrease in systolic blood pressure was 66 mm Hg.¹⁹ Significant ECG changes during bathing have also been reported.²⁰ Igarashi reported that 21 of 60 patients diagnosed with angina pectoris showed ECG changes (ischemic changes or arrhythmia) during baths.

3.3.2 | Changes in body temperature

A correlation between the rise in body temperature and hot water immersion was shown in an experiment with healthy young adults.²¹

The participants' body temperature reached 38.0°C after 7 minutes of hot water immersion (44°C), and 40°C after 10 minutes of hot water immersion. In contrast, the rise in body temperature was mild during immersion in water at 40°C. In addition, a deterioration of higher order brain function was observed after hot water immersion (44°C), but was not observed after water immersion at 40°C.

3.4 | Animal experiments

An experimental study using animals was conducted to clarify the correlation between heat exposure and mortality.¹⁵ In the experiment, 44 male Wistar rats anesthetized with sodium pentobarbital were immersed up to their shoulder in 40-45°C until respiratory arrest occurred or until they awoke from the anesthesia. All animals immersed in water heated to $\geq 41^\circ\text{C}$ died, whereas all animals immersed in 40°C water awakened. The body temperature of the animals that died during hot water immersion was above 41°C. In addition, water temperature was correlated with the interval from the start of immersion to respiratory arrest (ie, 41°C, 105 minutes; 42°C, 54 minutes; 43°C, 34 minutes; 44°C, 27 minutes; and 45°C; 22 minutes).

4 | FACTORS AFFECTING BATH-RELATED DEATHS

Analysis of autopsied cases revealed water inhalation signs in many cases^{4,5} and suggested that drowning may play an important role in the final process of bath-related death. This stage is often preceded by loss of consciousness due to the underlying etiology (Figure 3).

The underlying etiologies include all kinds of factors that induce unconsciousness and are roughly divided into diseases and non-disease-related factors as mentioned below. The hemodynamic changes induced by hot bath immersion may contribute to fatal events with or without underlying diseases/non-disease-related factors. The increase in both blood pressure and pulse rate immediately upon immersion may induce heart attack, whereas the decrease in both blood pressure and pulse rate several minutes after bathing may induce hypotensive syncope, resulting in drowning.¹⁸ In addition, orthostatic hypotension and loss of hydrostatic pressure may result in hypotensive syncope when one gets out of the water.¹⁹

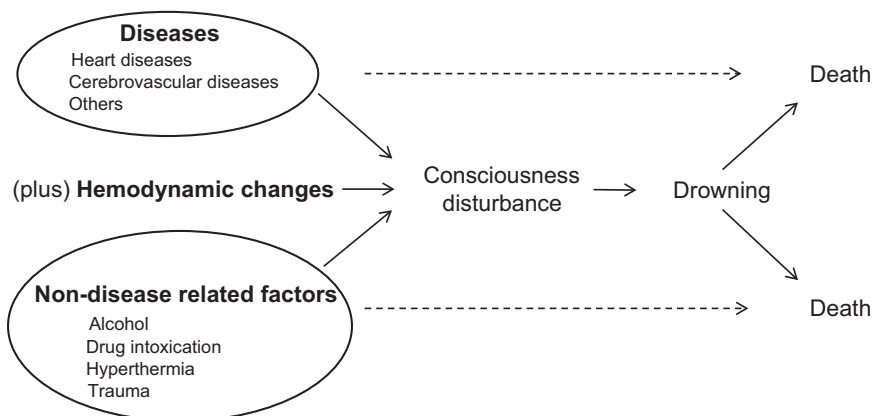


FIGURE 3 Mechanism of bath-related deaths

4.1 | Diseases

An underlying cardiac pathology, the most common autopsy finding in several studies,⁴⁻⁶ may be a primary underlying etiology. Although their numbers are smaller than those caused by circulatory diseases, various kinds of diseases other than circulatory diseases may contribute to bath-related death, which may affect the central nervous system (eg, epilepsy) and the heart (eg, cor pulmonare). Subsequent or coexisting dehydration may play a significant role in circulatory failure in conditions such as infectious diseases and metabolic disturbance (eg, ketoacidosis).⁵

4.2 | Non-disease-related factors

Intake of ethanol and psychotropic drugs may induce drowsiness, resulting in drowning in a bathtub. Traumatic lesions including intracranial injuries may also affect the consciousness level during bathing, although the number of such cases is quite small.⁵ Older persons have several physiological factors for increased heat susceptibility, such as a diminished perception of heat, and reduced sweat output.^{22,23} Hyperthermia induced by hot bath bathing might be critical problem for elder persons, resulting in exhaustion during bathing.

5 | CONCLUSION AND SUGGESTIONS

It is suggested that there are various causes for bath-related deaths, as mentioned above. However, there is still a controversy regarding the primary mechanism underlying bath-related deaths.²⁴ Emergency medicine physicians who assess survival cases state that forensic pathologists put too much emphasis on pathological findings, such as coronary artery stenosis and cardiomegaly, whereas forensic pathologists state that they cannot prove contribution of physiological factors, such as heat stroke and hypotensive syncope, by autopsy. This controversy may be partly attributed to the differences in study subjects (eg, survivors, nonsurvivors, patients in a mild or serious condition). It is possible that cases of heart attack may not be included in the survival cases. In addition, a certain proportion of autopsied cases showed no pathological or toxicological findings besides drowning, in which physiological factors might had played a significant role before

TABLE 4 Preventive strategies of bath-related death

Recognition of risk	Forecasting the risk of bath-related fatalities on the basis of air temperature Informing the public about the risk
Early detection	Taking care of elderly persons during bathing
Bathing	Inebriated or ill persons should not bathe Water below 41°C less than 10 minutes is recommended
Prevention of orthostatic hypotension	Stand up slowly when getting out of a bathtub

drowning. Therefore, at present, it is acceptable that various factors including diseases and non-disease-related factors may concern with bath-related deaths.²⁵

From the viewpoint of prevention, there are several measures that can be taken (Table 4). First, it is important to inform the public that bathing in a bathtub is potentially hazardous, especially among elderly persons. Family members should take care of elderly persons during bathing, especially in winter. Special attention should be paid to persons with circulatory diseases and epilepsy. Forecasting the risk of bath-related fatalities on the basis of air temperature may be useful in the future. Second, ill or inebriated persons should not bathe without supervision. A previous study indicated that preventive strategies for reducing alcohol-related deaths in bathtubs should target male habitual drinkers (middle-aged to seniors), and especially persons who have been diagnosed with alcohol-related diseases.⁶ Third, the water temperature and duration of immersion should be monitored. The body temperature of elder persons remained at 38°C or lower when they are immersed in 41°C water for 10 minutes.²⁵ Therefore, it is recommended that the temperature of the water used for bathing should be below 41°C and the immersion time should be less than 10 minutes. In addition, to prevent orthostatic syncope, it is recommended that elderly people should stand up slowly when they get out of bathtubs. As many victims of bath-related deaths have life-style-related diseases (Table 2) such as hypertension and diabetes mellitus, incorporating these preventive measures in the life/diet guidance of elderly patients with life-style related diseases may be effective.

Bath-related deaths rarely occur in nursing homes, and a great majority of these deaths occurs in the deceased's own residence (Table 1). This may be because staff in nursing homes take the appropriate precautions while observing elderly persons (eg, water temperature, immersion time). General physicians can judge whether elderly persons can take a bath while receiving nursing care services. They should take into account patients' vital signs, recent status, and past histories before judgment; however, excessive restrictions related to bathing should be avoided, because fatal events are considered to be rare under appropriate care in the nursing home. Patients who once lost consciousness during bathing should receive special attention, and general physicians should carefully examine changes in the vital signs (eg, blood pressure) of such patients before and after bathing, or check whether they have circulatory system diseases.

To elucidate both the manner and the cause of bath-related deaths, a comprehensive investigation incorporating a thorough scene investigation (eg, drinking, drug intake), determination of the victim's medical history (eg, heart disease), and detailed external examination (eg, signs suggestive of drowning, injury) is necessary because of the variability. The Japanese system for investigating sudden deaths is currently in the developmental stage, and the medical examiner system is implemented in only five large cities. In areas without the medical examiner system, general physicians are requested to perform postmortem examinations by the police.^{26,27} Because of the advent of a super-aging society, general physicians will have more chances to perform postmortem examinations of bath-related victims, especially in areas without the medical examiner system. If general physicians do not have enough experience of investigating bath-related deaths, they should consult forensic medicine experts in each area. If they cannot determine the manner and cause of death even after gathering full information of the deceased, they should recommend autopsies to the police. Careful postmortem examination will not only lead to accurate mortality statistics, but also provide more details regarding the mechanisms underlying bath-related deaths in the future.

CONFLICT OF INTEREST

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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How to cite this article: Suzuki H, Hikiji W, Fukunaga T. Bath-related deaths: Preventive strategies and suggestions for general physicians. *J Gen Fam Med.* 2017;18:21-26. <https://doi.org/10.1002/jgf2.17>