Original Article

Clinical relevance of impaired consciousness in accidental hypothermia: a Japanese multicenter retrospective study

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Aim: This study aimed to investigate the association between level of impaired consciousness and severe hypothermia (<28°C) and to evaluate the association between level of impaired consciousness and inhospital mortality among accidental hypothermia patients.

Methods: This was a multicenter retrospective study using the J-Point registry database, which includes data regarding patients whose core body temperature was 35.0°C or less and who were treated as accidental hypothermia in emergency departments between April 1, 2011 and March 31, 2016. We estimated adjusted odds ratios of the level of impaired consciousness for severe hypothermia less than 28°C and inhospital mortality using a logistic regression model.

Results: The study included 505 of 572 patients in the J-Point registry. Relative to mildly impaired consciousness (Glasgow Coma Scale [GCS] 13–15), the adjusted odds ratios for severe hypothermia less than 28°C were: moderate (GCS 9–12), 3.26 (95% confidence interval [CI], 1.69–6.25); and severe (GCS < 9), 4.68 (95% CI, 2.40–9.14). Relative to mildly impaired consciousness (GCS 13–15), the adjusted odds ratios for inhospital mortality were: moderate (GCS9–12), 1.65 (95% CI, 0.95–2.88); and severe (GCS < 9), 2.10 (95% CI, 1.17–3.78).

Conclusion: The level of impaired consciousness in patients with accidental hypothermia was associated with severe hypothermia and inhospital mortality.

Key words: Body temperature, consciousness, emergency medical service

BACKGROUND

ACCIDENTAL HYPOTHERMIA (AH) is a serious condition with high rates of morbidity and mortality.[1,2] In particular, severe hypothermia patients whose core body temperature (BT) is <28°C require intensive care management, such as extracorporeal rewarming and circulatory support, given the risks of life-threatening arrhythmia and

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cardiac arrest.[3] Therefore, the patient's BT is generally used as part of a severity scale to guide the selection of an appropriate medical facility.[1,4] However, measuring core BT such as the esophageal temperature is generally unavailable in prehospital settings.[5] Peripheral BT, such as axillary temperature. is typically used in the out-of-hospital setting; however, peripheral BT does not have clinically acceptable accuracy compared with core BT.[6] Therefore, a simple and reliable method is needed for estimating core BT and severity in the out-of-hospital setting.

We have traditionally used the Swiss staging system, which uses the level of consciousness and vital signs to estimate the core BT and triage the patient appropriately.[1] The Swiss staging system is commonly accepted worldwide; however, there is no high-quality evidence that the level of consciousness is valid for triage application.[7] In addition, little is known regarding level of consciousness guiding triage in cases of AH. Therefore, the present study had two aims: one was to clarify the association between the level of impaired consciousness and severe hypothermia in patients whose BT is less than 28°C, and the other was to determine the association between the level of impaired consciousness and inhospital mortality among patients with AH.

METHODS

Study design and setting

THIS MULTICENTER RETROSPECTIVE study used the J-Point registry database,[2,8] which has been previously described.[2,8–10] The registry includes data regarding patients with an unknown BT or those with a BT of 35.0°C or lower who were treated as AH in emergency departments between April 1, 2011 and March 31, 2016. The registry contains data from eight critical care centers and four non-critical care centers in the Osaka, Kyoto, and Shiga prefectures of Japan. These prefectures are not cold regions and, except for the northern part of the prefectures, there are many urban areas and little snowfall in winter. In Japan, a critical care center generally serves a population of 500,000 people and is certified by the Ministry of Health, Labor and Welfare of Japan to provide 24 h/day care to patients with severe trauma, severe shock, stroke, and acute coronary syndrome. The median number of patients who visit the emergency department at each facility is 19,651 (interquartile range [IQR], 13,281–27,554). Patients were excluded from the J-Point registry if they or their family members explicitly refused to be included in the registry. For the present study, clinical data were retrospectively extracted by emergency physicians using a predefined data extraction sheet. The J-Point registry protocol and retrospective analysis of anonymized data were approved by the ethics committee of Saiseikai Shiga Hospital (approval ID: 244). Each hospital also approved the registry protocol as necessary.

Study patients

This study included patients from the J-Point registry who were more than 18 years old and diagnosed with hypothermia. Based on a previous report,[1] hypothermia was defined as having a core BT of 35°C or lower. Patients were excluded if their BT was unknown, they had cardiac arrest at the hospital arrival, or had no record of consciousness level.

Data collection

We obtained clinical data from the J-Point registry database regarding age, sex, activities of daily living (ADL), medical history, vital signs at hospital arrival, blood test findings, comorbidities, and inhospital mortality. Age was categorized as 18–64, 65–74, and 75 years and older, based on age definitions reported from government statistical methods.[11] We also categorized the vital signs based on the Japan Fire and Disaster Management Agency protocol for triage.[12] Patients whose systolic blood pressure was difficult to measure were assigned a value of 60 mmHg or less and patients whose heart rate was difficult to measure were assigned a value of 30 b.p.m. or less. Data regarding respiratory status were not included in the analysis, as it is difficult to measure percutaneous arterial oxygen saturation in patients with hypothermia[13] and many patients were missing data regarding their respiratory rate.

Exposure

The primary exposure of interest was the level of consciousness at hospital arrival. The level of impaired consciousness was evaluated using the Glasgow Coma Scale (GCS) and the results were classified three groups: mild (GCS of 13–15), moderate (GCS of 9–12), or severe (GCS < 9). In Japan, the level of impaired consciousness is also evaluated using the Japan Coma Scale (JCS), which consists of eye-opening to stimuli, similar to the "eye" component of the GCS. The JCS is widely accepted by paramedics and nurses working in the emergency department, and is reportedly correlated with the GCS.[14] Therefore, when GCS data were missed, we imputed values for mildly impaired consciousness (JCS level 1, 1–3), moderately impaired consciousness (JCS level 2, 10–30), and severely impaired consciousness (JCS level 3, 100–300), based on previous reports.[8,9] The reason we used categorized levels of consciousness is that, in most prehospital severity assessment protocols used by

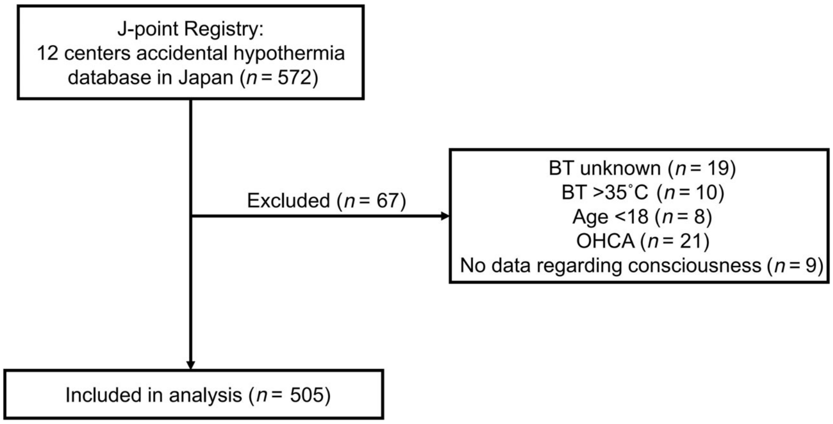

Fig. 1. Study flowchart to investigate the association between level of impaired consciousness and severe hypothermia. BT, body temperature; OHCA, out-of-hospital cardiac arrest.

emergency medical services in Japan and the Japan Triage and Acuity Scale used in the emergency department, the level of consciousness is categorized as based on GCS or JCS.[12,15] Thus, we believe that categorized levels of consciousness make it easier to interpret the results.

Outcomes

The primary outcome was defined as severe hypothermia at hospital arrival. According to the Swiss staging system, hypothermia was classified as stage 1 (BT, 32–35.0°C),

Table 1. Characteristics of patients with accidental hypothermia according to the degree of impaired consciousness

Parameter	All patients (*n* = 505)	Degree of impaired consciousness		
		Mild (GCS > 12) (*n* = 212)	Moderate (GCS 9–12) (*n* = 161)	Severe (GCS < 9) (*n* = 132)
Men	255 (50.5)	110 (51.9)	67 (41.6)	78 (59.1)
Age (years)	79 (68–87)	78 (67–87)	82 (70–88)	77.5 (66–87)
18–64	99 (19.6)	42 (19.8)	25 (15.5)	32 (24.2)
65–74	83 (16.4)	38 (17.9)	23 (14.3)	22 (16.7)
≥75	323 (64.0)	132 (62.3)	113 (70.2)	78 (59.1)
ADL				
Independent	350 (69.3)	150 (70.8)	104 (64.6)	96 (72.7)
Modified dependence	123 (24.4)	48 (22.6)	49 (30.4)	26 (19.7)
Complete dependence	30 (5.9)	12 (5.7)	8 (5.0)	10 (7.6)
Unknown	2 (0.4)	2 (0.9)	0 (0.0)	0 (0.0)
Medical history				
Cardiovascular	226 (44.8)	95 (44.8)	78 (48.4)	53 (40.2)
Neurological	90 (17.8)	37 (17.5)	28 (17.4)	25 (18.9)
Endocrine	128 (25.3)	53 (25.0)	35 (21.7)	40 (30.3)
Psychiatric	110 (21.8)	41 (19.3)	35 (21.7)	34 (25.8)
Malignant	16 (3.2)	7 (3.3)	4 (2.5)	5 (3.8)
Dementia	104 (20.6)	48 (22.6)	38 (23.6)	18 (13.6)
Unknown	7 (1.4)	3 (1.4)	3 (1.9)	1 (0.8)

Note: Data are shown as *n* (%) or median (interquartile range).
Abbreviations: ADL, activities of daily living; GCS, Glasgow Coma Scale.

stage 2 (BT, 28–31.9°C), stage 3 (BT, 24–27.9°C), and stage 4 (BT, <24°C).[1] For the present study, severe hypothermia was defined as stage 3–4 cases.[1] The secondary outcome was defined as all-cause inhospital mortality.

Statistical analysis

Patient characteristics at hospital arrival were analyzed according to the level of consciousness. Continuous variables were reported as medians and IQRs, and categorical variables were reported as numbers and percentages. As a primary analysis, the association between the level of impaired consciousness and severe hypothermia was evaluated by multivariable logistic model adjusted for the following potential confounders, as covariates that are generally available in the out-of-hospital setting: age, sex, ADL, consciousness, systolic blood pressure, and heart rate. Logistic regression analysis was used to evaluate the risk of severe hypothermia (BT, <28.0°C) according to level of impaired consciousness, and the results were reported as the crude odds ratio (COR) or adjusted odds ratio (AOR) with the corresponding 95% confidence interval (CI). Furthermore, the ability of impaired level of consciousness to predict severe hypothermia was evaluated based on the values for sensitivity, specificity, positive likelihood ratio (LR) and negative LR. As a secondary analysis, the association between the level of impaired consciousness and inhospital mortality was investigated by logistic regression analysis using the same covariates as potential confounders for the primary analysis. For evaluating the robustness of the results, we

Table 2. Data of patients with accidental hypothermia according to the degree of impaired consciousness

Parameter	All patients (*n* = 505)	Degree of impaired consciousness		
		Mild (GCS > 12) (*n* = 212)	Moderate (GCS 9–12) (*n* = 161)	Severe (GCS < 9) (*n* = 132)
Temperature (°C)	30.8 (28.4–32.6)	31.8 (30.1–33.1)	29.8 (28.0–32.3)	29.7 (26.2–32.0)
35.0–32	180 (35.6)	102 (48.1)	44 (27.3)	34 (25.8)
31.9–28	223 (44.2)	93 (43.9)	77 (47.8)	53 (40.2)
27.9–24	88 (17.4)	16 (7.5)	34 (21.1)	38 (28.8)
≤23.9	14 (2.8)	1 (0.5)	6 (3.7)	7 (5.3)
Heart rate (b.p.m.)	66 (50–84)			
≥50	379 (75.1)	173 (81.6)	117 (72.7)	89 (67.4)
31–49	107 (21.2)	36 (17.0)	39 (24.2)	32 (24.2)
≤30	19 (3.7)	3 (1.4)	5 (3.1)	11 (8.4)
Systolic blood pressure (mmHg)	119 (93–140)			
≥90	370 (73.3)	178 (84.0)	114 (70.8)	78 (59.1)
61–89	85 (16.8)	28 (13.2)	29 (18.0)	28 (21.2)
≤60	50 (9.9)	6 (2.8)	18 (10.2)	26 (19.7)
Laboratory findings				
pH	7.32 (7.25–7.37)	7.34 (7.29–7.38)	7.31 (7.24–7.38)	7.28 (7.19–7.35)
Lactate (mmol/L)	2.7 (1.3–5.85)	2.4 (1.3–4.6)	3.2 (1.55–7.55)	2.7 (1.0–6.55)
Sodium (mmol/L)	140 (135–143)	139 (136–143)	140 (136–143)	139 (134–143)
Potassium (mmol/L)	4.0 (3.6–4.6)	4.0 (3.6–4.5)	4.0 (3.6–4.9)	4.3 (3.5–4.7)
Comorbidities				
Infection	161 (31.9)	56 (26.4)	50 (31.1)	55 (41.7)
Stroke	21 (4.2)	8 (3.8)	2 (1.2)	11 (8.3)
Brain trauma	17 (3.4)	8 (3.8)	5 (3.1)	4 (3.0)
Intoxication	69 (13.7)	21 (9.9)	28 (17.4)	20 (15.2)
Hypoglycemia	38 (7.5)	13 (6.1)	11 (6.8)	15 (11.4)
Electrolyte abnormalities	13 (2.6)	1 (0.5)	7 (4.3)	5 (3.8)
Uremia	46 (9.1)	12 (5.7)	17 (10.6)	17 (12.9)

Note: Data are shown as *n* (%) or median (interquartile range).
Abbreviation: GCS, Glasgow Coma Scale.

undertook a sensitivity analysis adding the comorbidities as covariates in the logistic model. The details are described in Appendix S1 and S2. All analyses were carried out using JMP Pro 14 for Windows software (SAS Institute).

RESULTS

THE J-Point registry included 572 patients registered between April 1, 2011 and March 31, 2016. We excluded eight patients who were younger than 18 years old, 19 patients whose BT could not be measured or was not recorded, 11 patients whose recorded BT was higher than 35°C, 21 patients who were in cardiac arrest at hospital arrival, and nine patients with no data regarding level of consciousness. Thus, the study ultimately included 505 patients (Fig. 1).

Patient characteristics

Tables 1 and 2 show the patient characteristics and data. The median age was 79 years (IQR, 69–87 years) and the median BT was 30.8°C (IQR, 28.4–32.6°C). Figure 2 shows the relationships between impaired level of consciousness and BT. Inhospital mortality was recorded for 22.4% patients (113/505), including 14.6% patients with moderately impaired consciousness (31/212), 25.6% patients with mildly impaired consciousness (41/161), and 31.1% patients with severely impaired consciousness (41/132) (Fig. 3). Details of comorbidities and rewarming procedures are described in Tables S1 and S2.

Primary analysis

Relative to mild groups (GCS 13–15), the COR values for severe hypothermia were as follows: moderate group (GCS 9–12), 3.79 (95% CI, 2.06–6.99)' and severe group (GCS < 9), 5.93 (95% CI, 3.22–10.95). Relative to mild groups (GCS 13–15), the AOR values for severe hypothermia were as follows: moderate group (GCS 9–12), 3.26 (95% CI, 1.69–6.25); and severe group (GCS < 9), 4.68 (95% CI, 2.40–9.14; Fig. 4). For predicting severe hypothermia, severely impaired consciousness (GCS < 9) provided a sensitivity of 0.44 (95% CI, 0.34–0.54), specificity of 0.78 (95% CI, 0.74–0.82), a positive LR of 2.04, and a negative LR of 0.71. For predicting severe hypothermia, the combination of moderately (GCS9–12) or severely impaired consciousness (GCS < 9) provided a sensitivity of 0.83 (95% CI, 0.76–0.91), specificity of 0.48 (95% CI, 0.44–0.53), a positive LR of 1.61, and a negative LR of 0.34.

Secondary analysis

Relative to mild groups (GCS13–15), the COR values for inhospital mortality were as follows: moderate group (GCS9–12), 1.98 (95% CI, 1.18–3.34); and severe group (GCS < 9), 2.62 (95% CI, 1.54–4.45). Relative to mildly impaired consciousness, the AOR values for inhospital mortality were: moderate group (GCS9–12), 1.65 (95% C,: 0.95–2.88); and severe group (GCS < 9), 2.10 (95% CI, 1.17–3.78; Fig. 4).

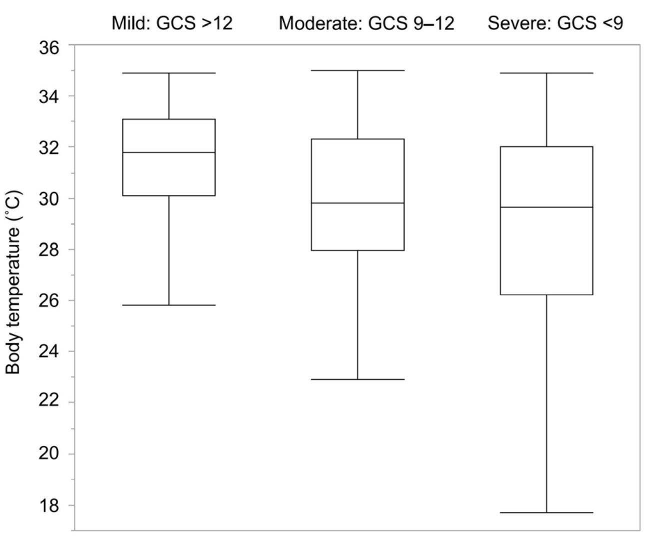

Fig. 2. Relationship between degree of impaired consciousness and core body temperature among 505 Japanese patients with severe hypothermia. GCS, Glasgow Coma Scale.

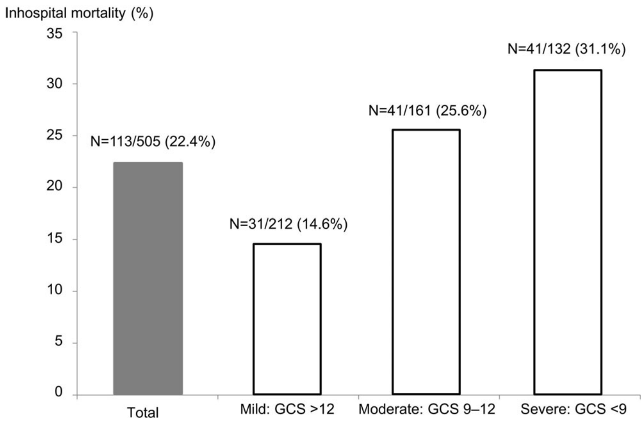

Fig. 3. Inhospital mortality according to degree of impaired consciousness among 505 Japanese patients with severe hypothermia. GCS, Glasgow Coma Scale.

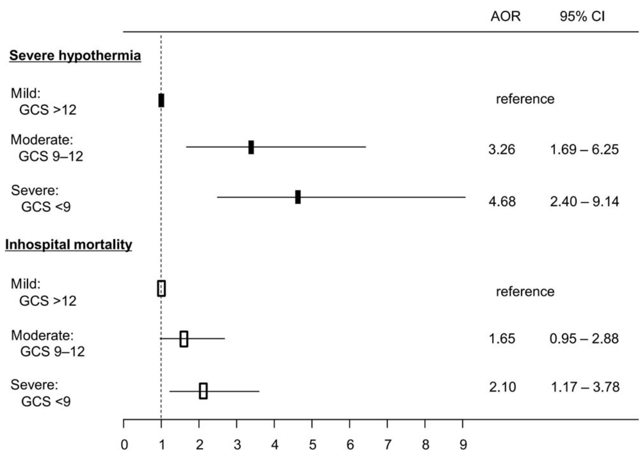

Fig. 4. Risk of severe hypothermia and inhospital mortality among 505 Japanese patients with severe hypothermia, according to degree of impaired consciousness. AOR, adjusted odds ratio; CI, confidence interval; GCS, Glasgow Coma Scale.

DISCUSSION

Key findings

THIS MULTICENTER RETROSPECTIVE study revealed the association between the level of impaired consciousness and severe hypothermia and between the level of impaired consciousness and inhospital mortality among patients with AH. We suggest that these results might be useful for predicting severe hypothermia and inhospital mortality among patients with AH.

Strength and previous findings

We believe that our study has two important strengths relative to previous studies. First, we undertook a multicenter study with a large sample of patients, whereas most previous studies have examined a small sample of patients at a single center.[16] Moreover, although some reports have addressed the validity of the Swiss staging system,[7,18] only one study directly analyzed the association between the level of impaired consciousness and core BT among AH patients, with the important limitation that it did not adjust the potential confounding factors.[19] Second, we evaluated patients who developed AH in urban areas, whereas previous studies have typically evaluated AH occurring in cold climates, such as the Alps.[16,17] In contrast, we evaluated a predominantly urban sample that included a large number of elderly people with underlying diseases, which suggests that our results could be generalizable to urban areas with aging populations.

Interpretation

The results of this study could be attributed to the following mechanisms. First, we suggest that a decrease in core BT might reduce brain activity and lead to a decreased level of consciousness. Previous studies in rats have shown that a decrease in BT causes a decrease in the permeability of the blood–brain barrier, which reduces the delivery of energy sources to brain cells.[20] Furthermore, studies of humans under surgical anesthesia with hypothermic circulatory arrest revealed reduced brain oxygen consumption[21] and suppressed electroencephalography that was correlated with a decrease in core BT.[22] Thus, it seems reasonable to assume that the level of impaired consciousness in severe hypothermia is caused by a decrease in brain activity that is related to a decreased core BT.

Clinical implications

We believe that this study has two clinical implications. First, it could potentially facilitate the prediction of severe hypothermia for patients with suspected AH in the out-of-hospital setting, where esophageal or rectal measures of core BT are unrealistic. This prediction could guide the transportation of patients to an appropriate medical facility where they can undergo invasive rewarming by extracorporeal membrane oxygenation. Furthermore, it may possibly be useful to treat these patients carefully during transport to avoid ventricular fibrillation. Second, the degree of impaired consciousness could be helpful in predicting the prognosis of AH patients. In the future, it might be possible to predict the prognosis of AH patients more accurately by combining the degree of impaired consciousness with other factors, which could be useful in determining the treatment plan. Therefore, our findings may be useful in both out-of-hospital and emergency care settings.

Limitations

The present study has some limitations. First, we excluded patients without information regarding the level of impaired consciousness, which might be a source of selection bias. Second, the retrospective design suggests that there was variability in the measurement site and timing of the core BT measurement. Third, evaluation of level of consciousness requires some skills and experience.[23,24] Although we believe that the medical staff at the participating emergency departments were likely well-trained, the validity of the assessments is also unclear and there is a risk of measurement bias. Fourth, there are two types of AH, primary and secondary, which are associated with other underlying conditions; however, it was difficult to distinguish them strictly in the actual clinical settings and also in the retrospective medical record review. The cause of secondary AH itself might have affected the level of consciousness and prognosis. These may be unadjusted confounding factors, potentially leading to the risk of bias. Fifth, we were not able to collect detailed data on cause of death, timing of death, or clinical course, including the withdrawal of invasive treatment or resuscitation. This might be an important limitation. Finally, this study was undertaken in an urban population in Japan, which has a high proportion of elderly people and might not be generalizable to AH patients in other regions (Table 1). Therefore, further prospective research is needed to validate our results and address these issues.

CONCLUSIONS

THIS MULTICENTER RETROSPECTIVE study of 505 patients with AH suggests that the level of impaired consciousness was associated with severe hypothermia and inhospital mortality. We suggest that level of impaired consciousness might be useful as a trigger to suspect severe hypothermia or a high inhospital mortality in triage.

DISCLOSURE

APPROVAL OF THE research protocol: The J-Point registry protocol and retrospective analysis of anonymized data were approved by the ethics committee of Saiseikai Shiga Hospital (approval ID: 244).

Informed consent: The need for informed consent was waived because of the retrospective nature of the study and the use of anonymous clinical data.

Registry and registration no. of the study/trial: N/A.

Animal studies: N/A.

Conflict of interest: None.

DATA AVAILABILITY

THE DATASET OF this study are not publicly available because ethics committees did not permit it, but editors are available from the corresponding author on reasonable request.

REFERENCES

1 Brown DJ, Brugger H, Boyd J, Paal P. Accidental hypothermia. N. Engl. J. Med. 2012; 367: 1930–8.

2 Matsuyama T, Morita S, Ehara N *et al*. Characteristics and outcomes of accidental hypothermia in Japan: the J-Point registry. Emerg. Med. J. 2018; 35: 659–66.
3 Paal P, Gordon L, Strapazzon G *et al*. Accidental hypothermia-an update : the content of this review is endorsed by the International Commission for Mountain Emergency Medicine (ICAR MEDCOM). Scand. J. Trauma Resusc. Emerg. Med. 2016; 24: 111.
4 Zafren K. Out-of-Hospital Evaluation and Treatment of Accidental Hypothermia. Emerg. Med. Clin. North Am. 2017; 35: 261–79.
5 Podsiadło P, Darocha T, Kosiński S, Sanak T, Gałązkowski R. Body temperature measurement in ambulance: a challenge of 21-st century? BMC Emerg. Med. 2019; 19: 44.
6 Niven DJ, Gaudet JE, Laupland KB, Mrklas KJ, Roberts DJ, Stelfox HT. Accuracy of peripheral thermometers for estimating temperature: a systematic review and meta-analysis. Ann. Intern. Med. 2015; 163: 768–77.
7 Pasquier M, Carron PN, Rodrigues A *et al*. An evaluation of the Swiss staging model for hypothermia using hospital cases and case reports from the literature. Scand. J. Trauma Resusc. Emerg. Med. 2019; 27: 60.
8 Okada Y, Matsuyama T, Morita S *et al*. Prognostic factors for patients with accidental hypothermia: A multi-institutional retrospective cohort study. Am. J. Emerg. Med. 2019; 37: 565–70.
9 Okada Y, Matsuyama T, Morita S *et al*. The development and validation of a “5A” severity scale for predicting in-hospital mortality after accidental hypothermia from J-point registry data. J. Intensive Care 2019; 7: 27.
10 Kandori K, Okada Y, Matsuyama T *et al*. Prognostic ability of the sequential organ failure assessment score in accidental hypothermia: a multi-institutional retrospective cohort study. Scand. J. Trauma Resusc. Emerg. Med. 2019; 27: 103.
11 Ministry of Health, Labour and Welfare website. Accessed on August 12, 2020. Available from: https://www.mhlw.go.jp/toukei/itiran/index.html
12 Japan Fire and Disaster Management Agency. Accessed on August 20, 2020. Available from: https://www.fdma.go.jp/mission/enrichment/appropriate/appropriate002.html
13 Striebel HW, Steinhoff U, Krause H, Kretz FJ. The reliability of pulse oximetry monitoring of arterial oxygen saturation in centrally intubated and hypothermic patients. Anasth. Intensivther. Notfallmed. 1988; 23: 200–4.
14 Okada Y, Kiguchi T, Iiduka R, Ishii W, Iwami T, Koike K. Association between the Japan Coma Scale scores at the scene of injury and in-hospital outcomes in trauma patients: an analysis from the nationwide trauma database in Japan. BMJ Open 2019; 9: e029706.
15 Funakoshi H, Shiga T, Homma Y *et al*. Validation of the modified Japanese Triage and Acuity Scale-based triage system emphasizing the physiologic variables or mechanism of injuries. Int. J. Emerg. Med. 2016; 9: 1.
16 Debaty G, Moustapha I, Bouzat P *et al*. Outcome after severe accidental hypothermia in the French Alps: a 10-year review. Resuscitation 2015; 93: 118–23.
17 Walpoth BH, Walpoth-Aslan BN, Mattle HP *et al*. Outcome of survivors of accidental deep hypothermia and circulatory arrest treated with extracorporeal blood warming. N. Engl. J. Med. 1997; 337: 1500–5.
18 Deslarzes T, Rousson V, Yersin B, Durrer B, Pasquier M. An evaluation of the Swiss staging model for hypothermia using case reports from the literature. Scand. J. Trauma Resusc. Emerg. Med. 2016; 24: 16.
19 Pasquier M, Cools E, Zafren K, Carron PN, Frochaux V, Rousson V. Vital signs in accidental hypothermia. High Alt. Med. Biol. 2021; 22: 142–7.
20 Krantis A. Hypothermia-induced reduction in the permeation of radiolabelled tracer substances across the blood-brain barrier. Acta Neuropathol. 1983; 60: 61–9.
21 McCullough JN, Zhang N, Reich DL, Juvonen TS, Klein JJ, Spielvogel D, et al. Cerebral metabolic suppression during hypothermic circulatory arrest in humans. Ann. Thorac. Surg. 1999; 67: 1895–9; discussion 919–21.
22 Stecker MM, Cheung AT, Pochettino A *et al*. Deep hypothermic circulatory arrest: I. Effects of cooling on electroencephalogram and evoked potentials. Ann. Thorac. Surg. 2001; 71: 14–21.
23 Bledsoe BE, Casey MJ, Feldman J *et al*. Glasgow coma scale scoring is often inaccurate. Prehosp. Disaster Med. 2015; 30: 46–53.
24 Basauhra Singh HK, Chong MC, Thambinayagam HC *et al*. Assessing nurses knowledge of glasgow coma scale in emergency and outpatient department. Nurs. Res. Pract. 2016; 2016: 8056350.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article at the publisher’s web-site:

Table S1. Comorbidities and inhospital mortality.
Table S2. Rewarming procedures for accidental hypothermia patients.
Appendix S1. Sensitivity analysis of primary analysis.
Appendix S2. Sensitivity analysis of secondary analysis.