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SNI: Neuroanesthesia and Critical Care

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Case Report

Surgical strategy for intracranial hemorrhage with accidental hypothermia in elderly individuals

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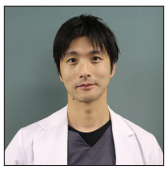

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Received: 23 August 2023
Accepted: 01 December 2023
Published: 05 January 2024

DOI
10.25259/SNI_707_2023

Quick Response Code:

ABSTRACT

Background: Accidental hypothermia poses a significant threat to the elderly, and its prevalence might increase due to aging and increasing isolation of individuals in Japan. Here, a series of four consecutive cases of accidental hypothermia in elderly patients with intracranial hemorrhage who underwent surgical treatment at our institution is presented.

Case Description: All patients were admitted to the emergency department with a diagnosis of intracranial hemorrhage. Among them, two patients experienced acute circulatory failure during emergency surgery, necessitating immediate cardiopulmonary resuscitation. Two other patients required intensive care before surgery; however, one of them exhibited signs of impending cerebral herniation, requiring emergency surgery.

Conclusion: Accidental hypothermia poses a significant threat to elderly individuals, carrying a substantial mortality risk and demanding intensive general care. During rewarming, careful considerations must be devoted to potential complications, such as ventricular fibrillation, rewarming shock, bleeding diathesis, and hyperkalemia. Despite these risks, many life-threatening cases necessitate emergency surgery and rewarming procedures in parallel. The formulation of a surgical strategy aimed at mitigating rewarming-related complications should be entrusted to anesthesiologists. Strict follow-up is required to increase intracranial pressure when prioritizing intensive care over surgery.

Keywords: Accidental hypothermia, Critical care, Geriatrics, Intracerebral hemorrhage, Intracranial hemorrhage, Surgery

INTRODUCTION

Accidental hypothermia is a major condition affecting elderly individuals. Approximately 50% of all deaths attributed to hypothermia occur in elderly individuals aged >65 years.[7] In Japan, a general survey on accidental hypothermia based on emergency case data revealed an increased occurrence among elderly patients, coupled with poor prognosis, as described below. The average age of the patients was 70.4 years, and the mortality rate was 29%. Cerebrovascular disease was the most common endogenous disease.[19] In Japanese society, characterized by the highest aging rates globally,[16] a concurrent rise of sudden death in the elderly single population is being witnessed.[5] This trend evokes concerns about a heightened incidence of accidental hypothermia cases linked to cerebrovascular diseases, yet viable solutions to this predicament remain elusive.

In this report, four reports of surgical interventions for intracranial hemorrhage with accidental hypothermia in the elderly have been outlined, along with a discussion on its clinical management with a literature review.

CASE PRESENTATION

We report the four consecutive cases of accidental hypothermia with intracranial hemorrhage that required surgical treatment at our institution [Table 1].

Case 1 was of an independent 85-year-old woman living with her son. She was discovered lying outdoors on her premises and was subsequently transported by ambulance. Her last documented well-being was tracked back to 24 hours earlier. On arrival, her condition indicated hypothermia (core body temperature [CBT] of 27.1°C; heart rate [HR] of 90 beats/min; and blood pressure [BP] of 173/119 mmHg), coupled with a neurological deficit (Glasgow coma scale [GCS] score at 4/15; anisocoria; and quadriplegia). Electrocardiography (ECG) confirmed the presence of J waves and a prolonged Q wave T wave interval. Head computed tomography (CT) revealed a hemorrhage in the right putamen with imminent cerebral herniation [Figure 1a]. Emergency surgery was performed to evacuate the hematoma. Intraoperatively, a hemodialysis catheter was inserted to initiate active internal rewarming. Subsequently, the patient developed an episode of ventricular fibrillation (VF). Timely defibrillation and cardiopulmonary resuscitation (CPR) were administered, resulting in the restoration of spontaneous circulation within 30 min. After the procedure, she commenced early rehabilitation. She was transferred to a medical care support hospital after 54 days with severe disability (modified Rankin scale [mRS], grade 5).

Case 2 was of an independent 83-year-old woman leading a solitary lifestyle. She had chronic renal failure and was undergoing hemodialysis. She was discovered lying at her residence and was transported to the emergency department. Her last documented well-being was tracked back to 24 hours prior. On evaluation, she exhibited hypothermia (CBT, 28.0°C; HR, 52 beats/min; BP, 145/72 mmHg), coupled with a neurological deficit (GCS score, 6/15; anisocoria; and hemiplegia). Head CT revealed a right acute subdural hematoma with imminent cerebral herniation [Figure 1b]. Emergency surgery with external decompression was performed to evacuate the hematoma. A hemodialysis catheter was inserted during surgery, and active internal rewarming was initiated. Subsequently, the patient developed bradycardia followed by pulseless electrical activity. Prompt CPR was administered, resulting in the restoration of spontaneous circulation within 10 min. After the surgery, she commenced early rehabilitation. She was transferred to a medical care support hospital after 43 days with severe disability (mRS, grade 5).

Table 1: Clinical characteristics of patients who developed hypothermia with intracranial hemorrhages.

Case	Age	Sex	Medical condition	Living style	Time between TLKW and arrival	CBT (°C)	GCS	Neurological deficit	Image finding	Surgical procedure	Operation	Outcome (6 month)
1	86	F	HT, OA	cohabitation	24hrs	27.1	4 (E1V1M2)	anisocoria, hemiparesis	ICH, herniation	removal	emergency	mRS: 5
2	83	F	HT, CHF, CRF (on HD)	solitude	24hrs	28	6 (E1V1M4)	anisocoria, hemiparesis	ASDH, herniation	removal + ED	emergency	mRS: 5
3	78	M	HT, CHF, Af	solitude	3days	25.8	9 (E4V1M4)	apallic state, hemiparesis	CSDH	drainage	3days later	mRS: 1
4	81	F	DM	solitude	5days	33.4	12 (E2V4M6)	apallic state	CSDH	drainage	8 days later	mRS: 1

HT: Hypertension, OA: Osteoarthritis, CHF: Chronic heart failure, CRF: Chronic renal failure, HD: Hemodialysis, Af: Atrial fibrillation, DM: Diabetes mellitus, TLKW: The time last known well, ICH: Incracerebral hemorrhage, ASDH: Acute subdural hemorrhage, CSDH: Chronic subdural hemorrhage, ED: External decompression, CBT: Core body temperature, GCS: Glasgow coma scale, mRS: modified Rankin Scale

Case 3 was of an independent 78-year-old man who was discovered collapsed in his bathroom and subsequently transported to the emergency department. His last documented well-being was traced back 3–4 days earlier. On assessment, he presented hypothermia (CBT, 25.8°C; HR, 66 beats/min; BP, 124/48 mmHg) with a neurological deficit (GCS score, 9/15; left hemiplegia). Head CT revealed a right subacute subdural hematoma with a midline shift of 18 mm [Figure 1c]. ECG confirmed the appearance of J waves. Blood test results revealed rhabdomyolysis and acute renal failure (ARF) [Table 2]. Subsequently, the decision was made to prioritize the amelioration of systemic conditions over emergency surgery, and active internal rewarming alongside intensive general care was initiated. Neurological monitoring and follow-up CT scans were performed. By the 3rd day, the state of consciousness disturbance had deteriorated, and a subsequent head CT revealed imminent cerebral herniation [Figure 1d]. Emergency drainage was performed to evacuate the hematoma. After surgery, the patient commenced early rehabilitation and achieved significant recovery. After 43 days, the patient was transferred to a rehabilitation hospital, where he continued to engage in rehabilitation efforts. The patient was discharged with an mRS grade of 1.

Case 4 was of an independent 81-year-old woman living alone who was discovered lying at her residence and subsequently transported to the emergency department. Her last documented well-being was tracked back to 5 days earlier. On arrival, she presented hypothermia (CBT, 33.0°C; HR, 98 beats/min; BP, 134/49 mmHg) with a neurological deficit (GCS score, 14/15; no paresis). Head CT revealed chronic bilateral subdural hematomas [Figure 1e]. In addition, she exhibited signs of severe dehydration, and blood tests revealed rhabdomyolysis and ARF [Table 2]. After careful assessment, it was decided that an emergency surgery was unwarranted. Instead, a strategy involving rewarming, intensive general care, and early rehabilitation was initiated. The patient's neurological status was followed up, and subsequent imaging was continued. By the 8th day, a decline in the level of consciousness was observed, and a subsequent head CT revealed an expanding mass effect in the right hemisphere [Figure 1f]. Prompt bilateral drainage was performed. After 25 days, she was transferred to a rehabilitation hospital, where rehabilitation efforts were continued, leading to her discharge with an mRS grade of 1.

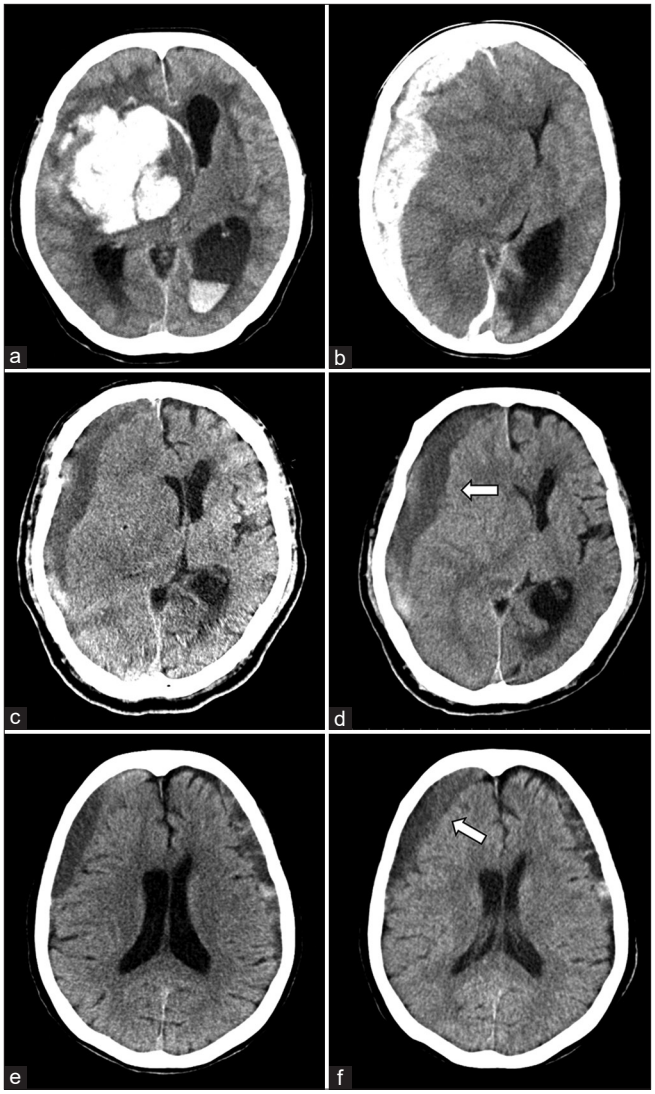


Figure 1: Imaging findings of patients who developed hypothermia with intracranial hemorrhage. (a) Axial non-contrast head computed tomography (CT) demonstrating a large acute intracerebral hematoma in the right putamen with imminent cerebral herniation. (b) Axial non-contrast head CT demonstrating a large acute subdural hematoma in the right hemisphere with imminent cerebral herniation. (c) Axial non-contrast head CT demonstrating a chronic subdural hematoma in the right hemisphere with a severe mass effect. (d) Follow-up imaging showed increased hematoma volume and mass effect. The white arrow indicates an increase in hematoma volume. (e) Axial non-contrast head CT demonstrating chronic subdural hematomas in both hemispheres with a mild mass effect. (f) Follow-up imaging showed an increased volume of the right subdural hematoma and a mass effect. The white arrow indicates blurriness of the sulcus due to the mass effect.

DISCUSSION

Accidental hypothermia is defined as an inadvertent reduction in CBT to below 35°C. Severity categorizations of accidental hypothermia are as follows: mild when CBT ranges between 35°C and 32°C, moderate when CBT ranges between 32°C and 30°C, and severe when CBT is below 30°C.[1] As the CBT declines, the functioning of body organs progressively declines, ultimately culminating in cardiorespiratory failure and potential fatality.[1,6] The mortality rate of accidental hypothermia is reported to be 17%[3] with indicators of poor outcomes,

Table 2: Laboratory findings of patients who developed hypothermia with intracranial hemorrhages.

Laboratory value	Reference range	case 1	case 2	case 3	case 4
White blood cells (× 10^3/μL)	3.3–8.6	14.5	8.8	10.2	12.9
Hemoglobin (g/dL)	13.7–16.8	15.9	10.5	17.4	13.8
Hematocrit (%)	40.7–50.1	46.2	30.8	50.9	41.8
Pletelets (× 10^9/L)	158–348	250	77	181	187
BUN (mg/dL)	8.0–20.0	15	23	143	129
Creatinine (mg/dL)	0.65–1.07	0.37	6.05	3.07	1.99
C-reactive protein (mg/L)	0.00–0.14	0.23	9.76	13.96	11.61
Creatine kinase (U/L)	59–248	543	32	6169	818
aPTT(s)	24.0–39.0	37.9	38.0	47.0	43.8
PT(s)	11.0–13.4	13.7	13.3	16	18.7
PT-INR	0.94–1.15	1.14	1.11	1.31	1.55
Na (mmol/mL)	138–145	133	134	149	156
K (mmol/dL)	3.6–4.8	3.6	3.2	4.8	4.5

BUN: Blood urea nitrogen, aPTT: Activated partial thromboplastine time, PT: Prothrombin time, INR: International normalized ratio

including advanced age and extended exposure periods.[15] Furthermore, elderly individuals are at high risk of developing accidental hypothermia due to comorbidities that compromise thermoregulation. Patients with cerebrovascular diseases are particularly prone to hypothermia due to their inability to avoid cold stress stemming from impaired consciousness, motor function, and hypothalamic thermoregulation dysfunction.[4] In addition, the hypothermic state itself affects the central nervous system and causes progressively declining consciousness, making it challenging to identify the coexistence of cerebrovascular diseases.[1] In the context of our three presented patients, all of whom experienced severe hypothermia with impaired consciousness, it is conceivable that their intracranial emergencies might have been subject to delays in diagnosis and intervention.

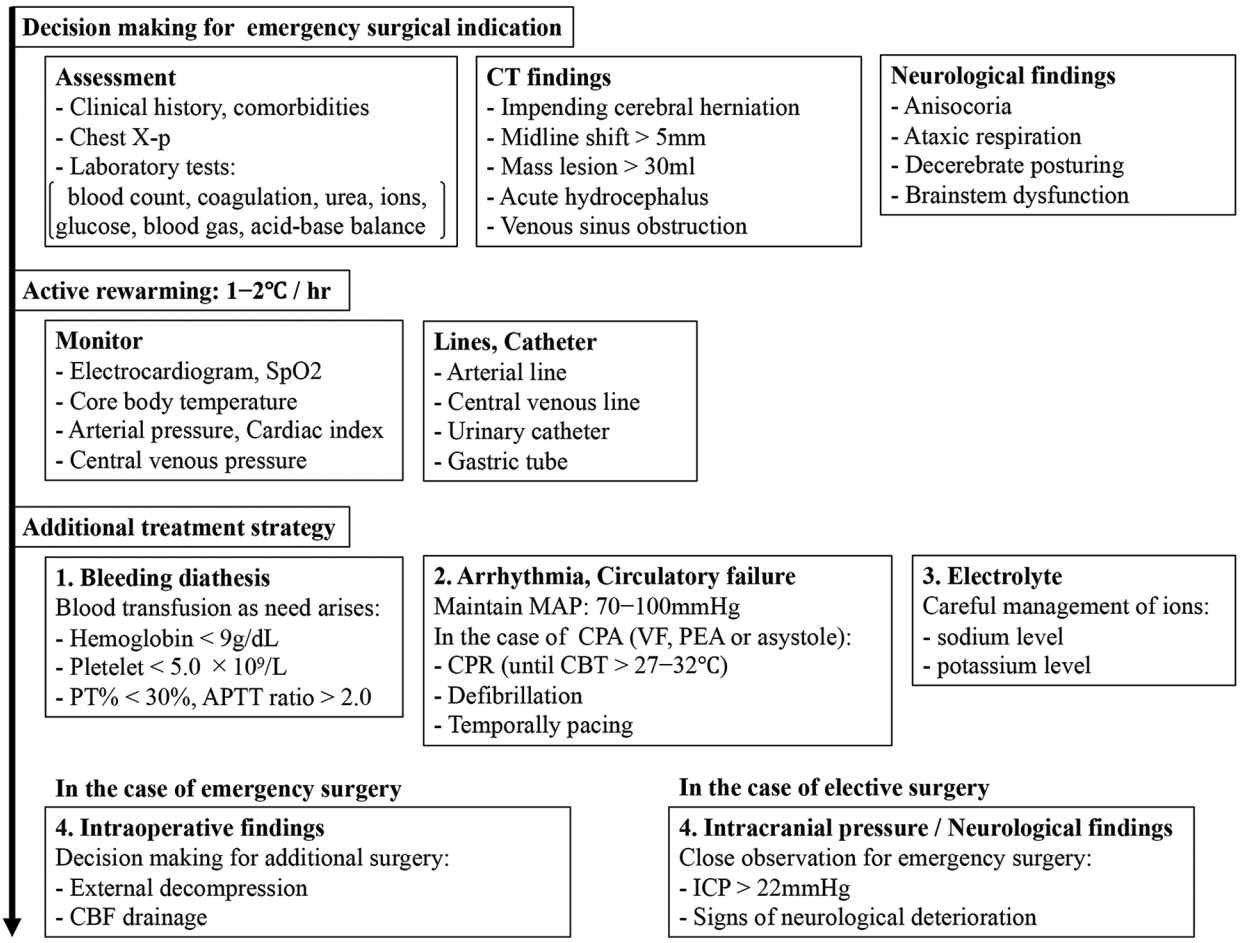
Hypothermia results in several physiological abnormalities, including dehydration, coagulopathy, electrolyte disturbances, respiratory failure, and cardiac dysfunction. As the severity of hypothermia increases, the cases of severe organ damage and fatality also increase.[18] On the other hand, therapeutic hypothermia is believed to confer neuroprotective benefits against brain injury through several mechanisms, such as decreasing neuronal metabolism, decreasing the release of excitatory amino acids, reducing the production of reactive oxygen species, reducing cell death, and protecting the blood-brain barrier.[13] Several reports have suggested the potential benefits of hypothermia in cases of intracranial hemorrhage in terms of improved neurological function.[2,8,9,11] However, the efficacy of hypothermia remains unestablished within systematic reviews and meta-analyses, and adverse consequences have been reported in terms of rewarming-associated complications.[10,14] The major complications of rewarming include VF, hypovolemic shock, and hyperkalemia. VF occurs due to abnormalities in the heart's conduction system induced by the temperature gradient variance between its internal and external environments. Hypovolemic shock results from the physical dilation of peripheral blood vessels, which can contribute to acute circulatory failure along with VF. Hyperkalemia arises from the altered dynamics of intracellular ion exchange. During hypothermia, cells take up potassium in a seemingly lowered manner due to the effects of low temperature. A rapid surge in rewarming follows this.[15] Moreover, attention should be paid to the increasing intracranial pressure (ICP) after rewarming. The mechanism of increased ICP is attributed to the swelling of damaged cells, particularly in cases involving damage to the brain parenchyma.[12,17] The rewarming techniques foraccidental hypothermia with intracranial hemorrhages is shown in Table 3. In our study, acute circulatory failure associated with rewarming occurred during emergency surgery in two cases. In contrast, a patient who received priority intensive care developed a cerebral herniation due to the rewarming process, necessitating emergency surgery. The proposed algorithm for management of hypothermia with intracranial hemorrhages is shown in Figure 2.

Given the prognosis of accidental hypothermia, prioritizing surgery for rewarming in cases of intracranial hemorrhage with accidental hypothermia is not advisable. First, surgical indications should be based on a comprehensive assessment of initial clinical symptoms and head CT findings. When a patient has acute hemorrhagic components and exhibits findings indicative of impending cerebral herniation, prompt emergency surgery should be performed concurrently with rewarming. However, it is crucial to remain vigilant about the potential complications associated with rewarming when dealing with emergency surgery. Adequate preparation for CPR is essential, particularly in cases of acute circulatory failure, when defibrillation or pharmacological interventions might yield no effect on severe hypothermia. In addition, low potassium levels in the blood might induce lethal arrhythmias;

Table 3: Rewarming techniques for accidental hypothermia with intracranial hemorrhages.

Categories	Rewarming technique	Rewarming rate	Indication
Passive external rewarming	warm environment and clothing	0.5 - 2 °C/hr	EMS / ELS
Active external rewarming	electrical or forced air heating packs / blankets	0.5 - 4 °C/hr	EMS / ELS
Active internal rewarming	Bladder lavage	0.5 - 1 °C/hr	ELS
	Gastric lavage	0.5 - 1 °C/hr	ELS
	Heated intravenous solutions	0.5 - 2.5 °C/hr	EMS / ELS
Active extracorporeal rewarming	Continuous venous hemofiltration	1.5 - 3 °C/hr	ELS
	Continuous venovenous rewarming	4 - 10 °C/hr	ELS
	Continuous arteriovenous rewarming	4 - 10 °C/hr	EMS / ELS

ELS: elective surgery, EMS: Emergency surgery



Abbreviations: CT, Computed tomography; CPA, Cardiopulmonary arrest; VF, Ventricular fibrillation; PEA, Pulseless electrical activity; CPR, cardiopulmonary resuscitation; CBT, core body temperature; CBF, cerebral blood flow; ICP, intracranial pressure; EMS, emergency surgery

Figure 2: The algorithm for management of hypothermia with intracranial hemorrhages. SpO2: Saturation of percutaneous oxygen, MAP: Mean arterial pressure.

however, such levels can rapidly rebound with rewarming, potentially escalating the risk factor of critical hyperkalemia with ARF. Considering these complications, a central venous route should be established to facilitate active internal

rewarming, enable prompt emergency hemodialysis, and allow for a large infusion in cases involving acute circulatory failure. Therefore, high-risk cases require multidisciplinary care, and effective collaboration with anesthesiologists is essential. In cases involving elective surgery, attention should be paid to the rapid deterioration of neurological symptoms due to increasing ICP associated with rewarming. Therefore, gradual rewarming and close observation using imaging and neurological monitoring should be performed.

In each of these cases, the interval between the most recent documented well-being and transportation was 24 hours. The context of societies characterized by a solitary lifestyle and advancing age could contribute to the development of accidental hypothermia among the elderly population. Given this demographic, it becomes imperative to revisit the strategies for the clinical management of intracranial hemorrhage with accidental hypothermia.

CONCLUSION

Herein, four consecutive cases of accidental hypothermia with intracranial hemorrhage in elderly patients have been reported. When addressing accidental hypothermia within the elderly population, it becomes imperative to entertain the possibility of intracranial hemorrhage. In the treatment setting, determining the indication for surgery according to neurological and imaging findings is essential. In the case of emergency surgery, due diligence must be exercised to mitigate the complications associated with rewarming. In the case of elective surgery, strict follow-up observations should be performed with attention to increasing ICP.

Ethical approval

Institutional Review Board approval is not required.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI.

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How to cite this article: Shinohara Y, Miyaoka R, Yamamoto J. Surgical strategy for intracranial hemorrhage with accidental hypothermia in elderly individuals. Surg Neurol Int. 2024;15:3. doi: 10.25259/SNI_707_2023