sciendo

Accidental hypothermia in the largest emergency hospital in North-Eastern Romania

LIDIA IONESCU[1,2], PAULA CRISTINA MORARIU [1,3,*], CRISTINA GENA DASCĂLU[1,4], DIANA ELENA IOV[1,3], ALEXANDRU FLORINEL OANCEA[1,5], CRISTINA PETRONELA CHIRIAC[1,3], OANA SÎRBU[1,3], DANIEL VASILE TIMOFTE[1,2], CIPRIAN REZUȘ[1,3], LAURENȚIU ȘORODOC[1,3], VICTORIȚA ȘORODOC[1,3], GENOVEVA LIVIA BAROI [1,2,**], DANIELA MARIA TANASE [1,3,**], MARIANA FLORIA[1,3,**]

[1] University of Medicine and Pharmacy "Grigore T. Popa", 16 University Street, 700115 Iasi, Romania;
[2] Surgery Clinic, "Sfântul Spiridon" Emergency Hospital, 700111 Iasi, Romania;
[3] Medical Clinic, "Sfântul Spiridon" Emergency Hospital 700111 Iasi, Romania;
[4] Department of Medical Informatics and Biostatistics; University of Medicine and Pharmacy "Grigore T. Popa", 16 University Street, 700115 Iasi, Romania;
[5] Cardiology Clinic, "Sfântul Spiridon" Emergency Hospital, 700111 Iasi, Romania;
[**] Joint senior author.

Abstract

Introduction: Accidental hypothermia (AH) presents a significant mortality risk, even in individuals with good health. Early recognition of the parameters associated with negative prognosis could save more lives.

Methods: This was a pilot, retrospective observational study, conducted in the largest Emergency Hospital in North Eastern Romania, which included all patients with AH (defined as body temperature below 35°C), hospitalized and treated in our hospital between 2019 and 2022.

Results: A total of 104 patients with AH were included in our study, 90 of whom had data collected and statistically analyzed. The clinical, biological, and therapeutic parameters associated with negative outcomes were represented by a reduced GCS score (p=0.024), diminished systolic and diastolic blood pressure (p=0.007 respectively, 0.013), decreased bicarbonate (p=0.043) and hemoglobin levels (p=0.002), the presence of coagulation disorders (p=0.007), as well as the need for administration of inotropic or vasopressor medications (p=0.04).

Conclusion: In this pilot, retrospective, observational study, the negative outcomes observed in patients with AH hospitalized in the largest Emergency Hospital in North-Eastern Romania were associated with several clinical, biochemical, and therapeutic factors, which are easy to identify in clinical practice. Recognizing the significance of these associated factors empowers healthcare practitioners to intervene at an early stage to save more lives.

Keywords: accidental hypothermia, prognosis, mortality, emergency medicine, intensive care.

What is new? What is important?

Accidental hypothermia can have major implications in patient survival if prompt management is not provided. This study presents the insights gained from the experience with accidental hypothermia in the biggest Emergency Hospital in the North Eastern Romania, emphasizing the distinctive clinical, biochemical and therapeutically factors linked to unfavorable outcomes, which are the same with those published in the literature.

INTRODUCTION

Hypothermia is a medical condition that occurs when the body loses heat faster than it can produce it, resulting in a dangerously low body temperature. The normal body temperature is around 37°C (98.6°F), and hypothermia typically becomes clinically relevant when the body temperature drops below 35°C (96.8°F). The classification of hypothermia is typically based on the body's temperature, with distinctions for mild (32° to 35°), moderate (28° to 32°), and severe cases (< 28°) [1].

Accidental hypothermia (AH) is the unintentional lowering of body temperature, distinct from therapeutic hypothermia, which is a controlled reduction of body temperature for medical purposes [2]. Therapeutic hypothermia, also known as induced hypothermia or targeted temperature management,

is a proven neuroprotective treatment for conditions like traumatic brain injury, stroke, and cardiac arrest-induced ischemia. It has demonstrated positive effects on both survival rates and neurological outcomes [3,4].

While uncommon, AH presents substantial risks, even for individuals in good health, which is why it is categorized as a "low-frequency, high-consequence" condition [5]. Hypothermia can worsen quickly, especially in severe environmental conditions or if appropriate measures are not taken promptly. The occurrence of hypothermia has been independently linked to heightened mortality in cases of trauma, sepsis, or respiratory infections [6–9].

We aimed to establish the clinical, biochemical, and therapeutic particularities associated with negative outcomes in patients with AH and to compare our results to the data present in the literature. This study represents, also, the experience of the biggest Emergency Hospital in North-Eastern Romania regarding AH.

MATERIALS AND METHODS

PATIENT ENROLMENT AND DATA COLLECTION

This retrospective observational study conducted at "Sfântul Spiridon" Emergency Hospital, the largest emergency hospital in North-Eastern Romania, focused on patients with AH (defined as core temperature below 35°C) over a three-year period from January 1st, 2019, to December 31st, 2022.

We included all patients who were hospitalized for the severity of signs and symptoms of the AH, which was documented pre-hospital by measuring core temperature at the tympanic level. Data were extracted from patient files. Patients with limited/ incomplete medical data were excluded.

Clinical, biochemical, and therapeutic parameters, along with associated disorders were collected. Patients were categorized into two groups based on their condition at discharge. The control group consisted of individuals whose condition showed improvement during their hospitalization, as indicated by clinical and paraclinical data. This group also incorporated patients with stable general condition, who were ineligible for continued emergency hospitalization and were subsequently transferred to another care facility for long-term observation. The study group comprised patients who died during their hospitalization, due to a steadily deteriorating general condition.

Collected data included age, sex, social status, typmanic core temperature, vital parameters (heart rate, respiration rate, systolic and diastolic blood pressure – SBP and DBP), comorbidities, mental illnesses, alcohol intoxication, Glasgow Coma Scale (GCS), cardiac arrest, intubation, and length of hospital stay. Inotropes and vasopressor requirements were noted. Pulmonary infections at admission were diagnosed by the characteristic appearance on chest radiography or computed tomography. Complications during hospitalization were noted and classified as arrhythmias (recorded on 12-lead surface electrocardiogram – ECG), or coagulopathies (diagnosed through modified blood tests that assess platelet function, and coagulation parameters like platelet count, Prothrombin Time, activated Partial Thromboplastin Time, INR, fibrinogen, and D-dimer).

For the patients' biochemical profiles, we gathered information on their hematological profile, blood sugar, potassium level, lactate, lipase, and fibrinogen. The pH value of every patient, along with Partial Pressure of Oxygen (PaO_2), Partial Pressure of Carbon Dioxide ($PaCO_2$), and bicarbonate (HCO_3^-), were evaluated by an arterial blood gas (ABG) analysis.

The primary outcome was the mortality of patients with AH during hospitalization. Secondary outcomes were GCS, BP values, pH values, and hemoglobin levels of patients with AH.

This is a pilot, retrospective, observational study, initiated with the desire to determine the parameters associated with negative outcomes and, if there is potential to expand the research and create a larger database of patients with AH.

The study was approved by the Ethics Committee of the "Sfântul Spiridon" Emergency Hospital, Iași (no. 95/5.10.2023).

STATISTICAL ANALYSIS

Statistical analysis was performed using the SPSS version 29.0 software package (SPSS Inc., Chicago, IL, USA). Categorical variables were presented as frequencies and percentages, and continuous variables as mean ± standard deviation.

Categorical and ordinal variables were compared between groups using the $\chi 2$ test and continuous variables were compared between groups using the Student-t test/ ANOVA test and Mann-Whitney / Kruskal-Wallis test (when the pre-condition of normal repartition of values was not verified). Statistical significance was assessed at a value of $p< 0.05$, and the confidence interval (CI) was 95%.

RESULTS

After applying the exclusion criteria, 90 out of the initial 104 patients diagnosed with AH were included (Figure 1**)**. They were categorized into two groups based on discharge status: the study group (n=35) included patients who died while hospitalized, and the comparing group (n=55) consisted of those with improved, or stationary (transferred to another hospital for follow-up) health status.

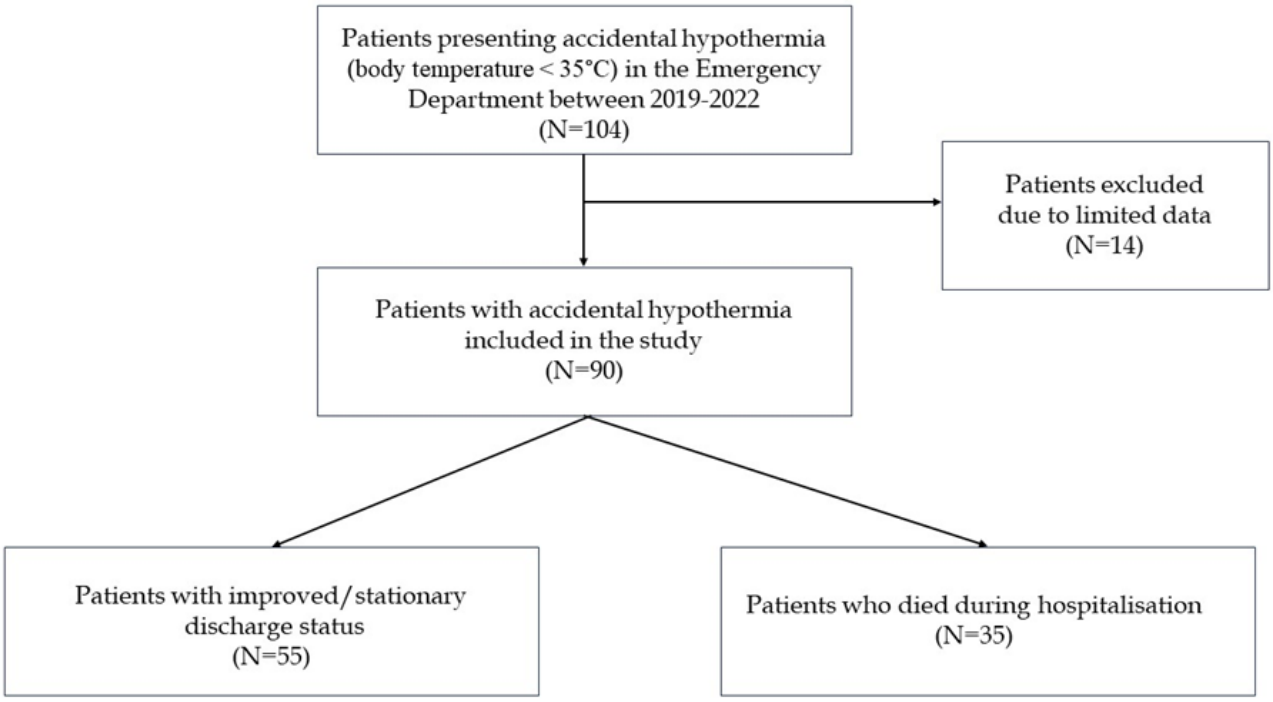

Figure 1. Flowchart of the study population.

BASELINE CHARACTERISTICS OF THE STUDY POPULATION

Table 1 summarizes the baseline characteristics of 90 patients in this retrospective study, divided by discharge status – improved/ stationary or deceased. The cohort consists of 27.4% females and 72.6% males, with a mean age of 62.33 years. The core temperature among hospitalized hypothermic patients was 28.91 ± 3.38°C, with no significant difference between the studied groups. Among the hospitalized patients with AH, 31.6% were living alone, and 20% of all patients were homeless. GCS scores at admission were lower in the deceased group (8.74 vs. 11.15 points, p=0.024). Although there were no notable differences in core body temperature, heart rate, or respiratory rate, distinctions were observed in SBP and DBP. The improved/stationary group exhibited higher SBP values (119.16 mmHg vs. 101.72 mmHg, p=0.007), while the deceased group had lower DBP values (74.87 mmHg vs. 63.63 mmHg, p=0.013).

Furthermore, we performed ROC curve analysis for GCS, SBP, and DBP. The ROC curve analysis (Figure 2) showed that the area under the curve (AUC) for GCS was 0,359 (0,238 ÷ 0,481), for SPB was 0,319 (0,201 ÷ 0,437), and for DBP was 0,331 (0,198 ÷ 0,464). Based on these AUC values, GSC, SPB and DBP may have limited accuracy in predicting negative outcomes.

Table 1

General characteristics of patients with accidental hypothermia

Parameter	Overall (n = 90)	Patient discharge status		P-value
		Improved/ stationary (n = 55)	Deceased (n = 35)	
Age (years)	62.33 ± 16.001	61.58 ± 16.895	64.23 ± 15.286	0.454
Gender				0.192
Male	69 (72.6%)	43 (78.2%)	23 (65.7%)	
Female	26 (27.4%)	12 (21.8%)	12 (34.3%)	
Social status				
Living alone	30 (31.6%)	16 (29.1%)	11 (31.4%)	0.813
Homeless	19 (20.0%)	11 (20.0%)	6 (17.1%)	0.736
Temperature (◦C)	28.911 ± 3.3851	28.942 ± 3.4870	28.654 ± 3.3597	0.700
GCS (points)	10.06 ± 4.363	11.15 ± 3.861	8.74 ± 4.693	0.024*
Systolic BP (mmHg)	112.37 ± 29.522	119.16 ± 28.324	101.72 ± 29.166	0.007*
Diastolic BP (mmHg)	71.53 ± 20.028	74.87 ± 18.520	63.63 ± 20.279	0.013*
Heart rate (/min)	79.63 ± 28.917	76.85 ± 30.093	80.40 ± 25.549	0.362
Respiratory rate(/min)	17.89 ± 4.674	17.41 ± 4.351	18.77 ± 4.985	0.164

* Statistical significance ($p < 0.05$); BP: blood pressure; GCS: Glasgow Coma Scale

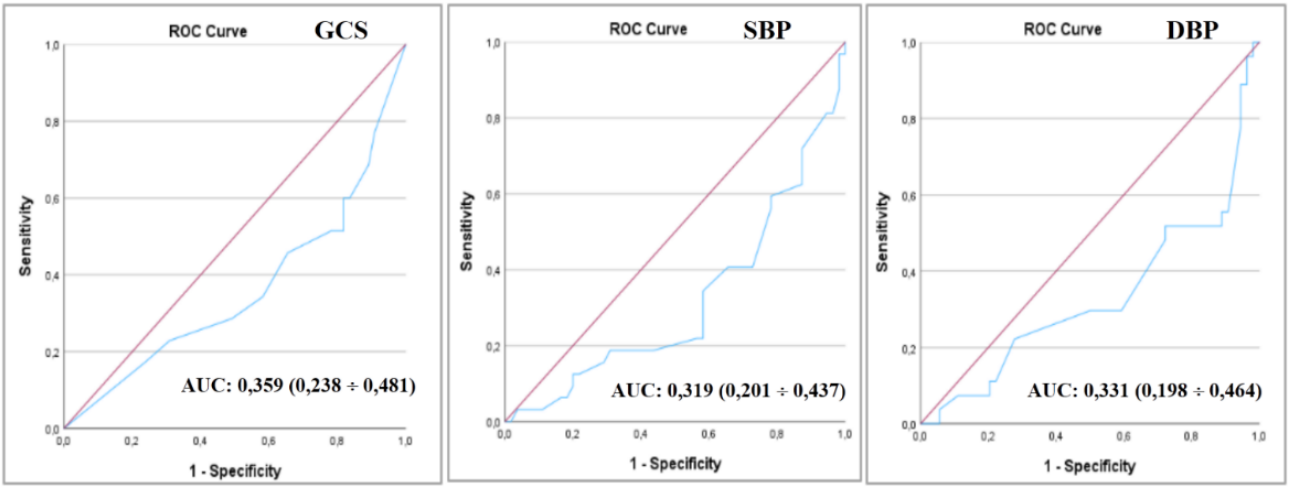

Figure 2. Area under the curve (ROC curve) analysis for Glasgow Coma Scale (GCS), Systolic Blood Pressure (SBP), and Diastolic Blood Pressure (DBP) in patients with accidental hypothermia.

CLINICAL AND BIOLOGICAL DATA

The biological data of the study population are presented in Table 2. Lipase levels were higher among patients with negative outcomes (179.19 ± 347.06 U/L vs. 131.23 ± 284.08 U/L, p> 0.05). Non-survivors had much higher mean glycemic levels (213.77 ± 205.2 mg/dl vs 148.3 ± 89.9 mg/dl, p=0.133). In addition to poor social status, alcohol consumption was another cause of hypothermia. In our research, patients who showed improvement in their overall condition exhibited higher blood ethanol levels in contrast to those who did not survive (148.50 ± 157.542 g/l vs. 87.68 ± 139.056 g/l). However, the statistical significance of these data is missing. While the deceased group showed a higher PaO2 value (98.69 ± 106.82 mmHg vs. 68.14 ± 56 mmHg), the difference lacked statistical significance. Additionally, there were no significant differences in leukocyte levels, fibrinogen, potassium, lactate, or blood ethanol levels.

Nevertheless, there were statistically significant differences in pH values when comparing the two study groups (7.257 ± 0.1285 in the improved/ stationary group vs. 7.156 ± 0.1925 in the deceased study group, p=0.009). Hemoglobin levels were lower among patients in the deceased group (10.934 ± 3.2102 g/dl vs. 12.940 ± 1.9710 g/dl, p=0.002). Bicarbonate levels also varied significantly between the groups (20.933 ± 5.9954 mmol/l vs. 18.239 ± 5.8108 mmol/l, p=0.043).

Regarding comorbidities (Table 3), no statistically significant differences were found between the study groups. However, diabetes (33.3%), liver cirrhosis (60%), and arterial hypertension (51.7%) prevalence was not significantly higher among hypothermic with negative outcomes. Coagulation disorders were present in 43.3% of all hospitalized patients, with significantly higher occurrence in the deceased group, where 60.6% had coagulation disorders (p=0.007). The occurrence of arrhythmias did not differ significantly between the two patient groups.

Among all study patients, 45.6% required oro-tracheal intubation during hospitalization, with a higher need in the deceased group, along with more frequent cardiopulmonary resuscitation (CPR) (p<0.001). Additionally, the deceased group had a higher percentage requiring inotropic or vasopressor substances (53.3% vs. 20%, p=0.040) (Table 4). Patients with unfavorable outcomes had a significantly shorter mean hospitalization duration of 5.67 ± 7.84 days (p=0.010).

Table 2

Biological data of patients with accidental hypothermia

Parameter	**Overall (n = 90)**	**Patient discharge status**		**p-value**
		Improved/ stationary (n = 55)	**Deceased (n = 35)**	
pH	7.216 ± 0.1603	7.257 ± 0.1285	7.156 ± 0.1925	0.009*
PaO2 (mmHg)	80.055 ± 77.6517	68.140 ± 56.0016	98.697 ± 106.8208	0.241
PaCO2 (mmHg)	49.373 ± 16.7481	48.636 ± 14.6221	49.920 ± 19.4626	0.819
Potassium (mmol/l)	4.017 ± 1.0252	4.094 ± .8467	4.073 ± 1.2370	0.480
Leukocytes (/µL)	8569.05 ± 5341.935	8663.99 ± 5469.256	8291.14 ± 5373.883	0.843
Hemoglobin (g/dl)	12.183 ± 2.6488	12.940 ± 1.9710	10.934 ± 3.2102	0.002*
Lipase (U/L)	145.323 ± 299.2032	131.233 ± 284.0854	179.192 ± 347.0606	0.431
Fibrinogen (mg/dl)	312.30 ± 100.036	315.06 ± 103.835	299.25 ± 108.896	0.789
Glucose (mg/dl)	181.75 ± 163.282	148.33 ± 89.950	213.77 ± 205.208	0.133
Blood Ethanol (g/l)	130.38 ± 153.649	148.50 ± 157.542	87.68 ± 139.056	0.123
Lactate (mmol/l)	5.350 ± 4.3056	5.152 ± 4.5945	5.626 ± 3.9306	0.370
Bicarbonate (mmol/l)	19.790 ± 5.9756	20.933 ± 5.9954	18.239 ± 5.8108	0.043*

* Statistical significance (p < 0.05).

Table 3

Data regarding comorbidities and complications of patients with accidental hypothermia

Parameter	Overall (n = 90)	Patient discharge status		p-value
		Improved/ stationary (n = 55)	Deceased (n = 35)	
Comorbidities				
Lung infections	49 (55.1%)	30 (56.6%)	16 (51.6%)	0.657
Diabetes mellitus	23 (28.7%)	13 (27.1%)	9 (33.3%)	0.568
HTN	34 (41.0%)	18 (36.7%)	15 (51.7%)	0.195
Liver cirrhosis	51 (59.3%)	31 (59.6%)	18 (60.0%)	0.973
Alcohol intoxication	39 (47.0%)	24 (45.3%)	13 (50.0%)	0.693
Mental disorders	36 (43.9%)	25 (47.2%)	11 (44.0%)	0.793
Complications				
Coagulation disorders	39 (43.3%)	16 (30.8%)	20 (60.6%)	0.007*
		OR (95% CI):	3.462 (1.389 ÷ 8.629)	
Arrhythmia	36 (41.4%)	22 (43.1%)	13 (41.9%)	0.915

* Statistical significance ($p < 0.05$); HTN: Hypertension.

Table 4

Therapeutic measures of patients with accidental hypothermia

Parameter	Overall (n = 90)	Patient discharge status		p-value
		Improved/ stationary (n = 55)	Deceased (n = 35)	
Therapeutic measures				
Intubation	41 (45.6%)	9 (17.0%)	27 (84.4%)	<0.001*
		OR (95% CI):	26.400 (8.003 ÷ 87.093)	
CPR	29 (33.3%)	3 (5.9%)	23 (74.2%)	<0.001*
		OR (95% CI):	46.000 (11.153 ÷ 189.726)	
Antiarrhythmic drugs	8 (9.0%)	3 (5.7%)	4 (12.9%)	0.415
Inotropes/vasopressors drugs	12 (33.3%)	4 (20.0%)	8 (53.3%)	0.040*
Hospitalization (days)	7.09 ± 6.937	8.11 ± 6.296	5.67 ± 7.844	0.010*

* Statistical significance ($p < 0.05$); CPR: Cardiopulmonary Resuscitation.

A ROC curve analysis (Figure 3) performed for pH values showed an AUC of 0.333 (0.210 ÷ 0.457), for hemoglobin levels was 0.292 (0.175 ÷ 0.410), and for bicarbonate levels was 0.361 (0.244 ÷ 0.479). Based on these AUC values, the accuracy of pH, hemoglobin, and bicarbonate levels in predicting negative outcomes may be limited.

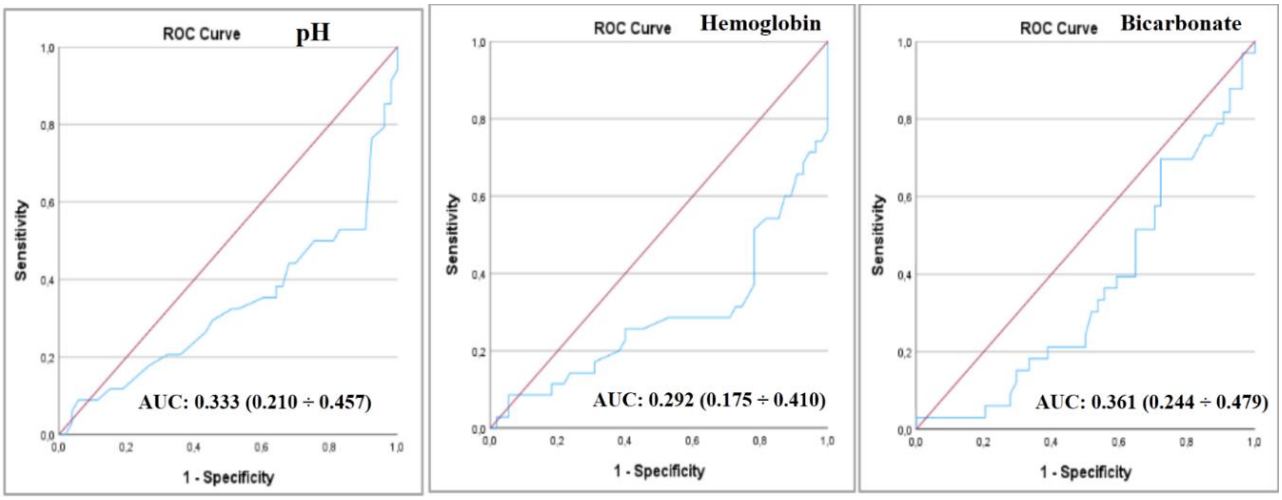

Figure 3. Area under the curve (ROC curve) analysis for pH values**,** hemoglobin levels, and bicarbonate levels in patients with accidental hypothermia.

ACCIDENTAL HYPOTHERMIA IN ICU ADMITTED PATIENTS

We conducted an additional statistical analysis within our study group, which included patients who were orally intubated, orally intubated and experiencing hemodynamic instability, hemodynamically unstable patients, and those without either complication. Interestingly, we found that the same variables remained significant as in the initial statistical analysis for the entire patient cohort, including GC score, SBP, and pH levels. Specifically, patients who were hemodynamically unstable and/or orally intubated exhibited lower pH and GCS coma scores, along with lower SBP compared to the control group. Moreover, significantly elevated fibrinogen levels were observed in hemodynamically unstable and/or orally intubated patients, and their hospitalization was complicated by the occurrence of arrhythmias. Detailed statistical results are provided in the Table 5.

Table 5

Patient status

Statistical variables of patients with accidental hypothermia admitted in ICUParameter	**Patient status**				
	Orotraheal intubated (n = 33)	**Orotraheal intubated and hemodynamically unstable (n = 8)**	**Hemodynamically unstable (n = 4)**	**Stable patients (n = 50)**	**p-value**
Age (years)	58.97 ± 15.400	71.75 ± 17.078	50.75 ± 15.435	63.96 ± 15.630	0.075
Gender					0.076
Male	25 (75.8%)	3 (37.5%)	2 (50.0%)	39 (78.0%)	
Female	8 (24.2%)	5 (62.5%)	2 (50.0%)	11 (22.0%)	
Social status					
Living alone	10 (30.3%)	3 (37.5%)	2 (50.0%)	15 (30.0%)	0.840
Homeless	6 (18.2%)	1 (12.5%)	-	12 (24.0%)	0.604
Temperature (◦C)	29.39 ± 3.019	29.54 ± 2.31	26.98 ± 3.205	28.65 ± 3.748	0.477
GCS (points)	8.24 ± 4.697	8.38 ± 4.719	6.5 ± 5.686	11.82 ± 3.173	0.003*
Systolic BP (mmHg)	115.2 ± 32.161	83.25 ± 34.681	97.25 ± 18.355	116.54 ± 25.184	0.015*
Diastolic BP (mmHg)	71.83 ± 21.009	47 ± 25.583	79 ± 1.414	73.55 ± 17.907	0.140

Table 5 (continued)

Statistical variables of patients with accidental hypothermia admitted in ICUParameter	**Patient status**				
	Orotraheal intubated (n = 33)	**Orotraheal intubated and hemodynamically unstable (n = 8)**	**Hemodynamically unstable (n = 4)**	**Stable patients (n = 50)**	**p-value**
Heart rate (/min)	81.18 ± 28.005	74.63 ± 36.284	75 ± 26.658	79.78 ± 29.204	0.861
Respiratory rate(/min)	17.68 ± 5.146	16.00 ± 4.000	18.33 ± 1.528	18.24 ± 4.645	0.880
pH	7.193 ± 0.1496	7.086 ± 0.21	7.18 ± 0.1299	7.256 ± 0.1497	0.023*
PaO_2 (mmHg)	100.063 ± 93.7267	123.05 ± 143.8166	83.5 ± 39.4504	60.535 ± 43.583	0.125
$PaCO_2$ (mmHg)	50.963 ± 21.1871	62.312 ± 20.5358	52.125 ± 7.4875	45.95 ± 12.2869	0.108
Potassium (mmol/l)	3.775 ± 1.176	4.513 ± 1.0077	4.650 ± 1.8912	4.042 ± 0.8025	0.150
Leukocytes (/µL)	9791.21 ± 5641.486	7358.75 ± 3518.122	7090.00 ± 6345.660	8074.39 ± 5296.376	0.317
Hemoglobin (g/dl)	12.385 ± 2.7110	11.400 ± 2.3767	11.200 ± 3.6469	12.254 ± 2.6129	0.694
Lipase (U/L)	151.464 ± 234.4716	24.286 ± 10.1606	11.000	164.600 ± 358.5535	0.073
Fibrinogen (mg/dl)	279.00 ± 62.821	455.00 ± 41.012	522.00	294.55 ± 94.210	0.009*
Glucose (mg/dl)	211.33 ± 171.360	261.00 ± 360.031	81.25 ± 79.198	157.58 ± 100.158	0.083
Blood Ethanol (g/l)	113.35 ± 152.512	0.00	200.50 ± 142.128	144.61 ± 158.023	0.142
Lactate (mmol/l)	5.648 ± 4.1886	3.829 ± 2.2478	4.300 ± 1.8312	5.538 ± 4.9333	0.926
Bicarbonate (mmol/l)	19.006 ± 5.8603	19.888 ± 3.8952	17.925 ± 3.5246	20.452 ± 6.5014	0.682
Comorbidities					
Lung infections	19 (59.4%)	3 (37.5%)	2 (50.0%)	25 (55.6%)	0.733
Diabetes mellitus	8 (26.7%)	2 (33.3%)	2 (100.0%)	11 (26.2%)	0.157
HTN	9 (30.0%)	7 (87.5%)	-	18 (41.9%)	0.018*
Liver cirrhosis	21 (67.7%)	2 (33.3%)	3 (75.0%)	25 (55.6%)	0.353
Alcohol intoxication	15 (50.0%)	1 (20.0%)	2 (100.0%)	21 (45.7%)	0.277
Mental disorders	11 (36.7%)	3 (60.0%)	-	22 (48.9%)	0.364
Complications					
Coagulation disorders	18 (58.1%)	2 (25.0%)	1 (25.0%)	30 (63.8%)	0.116
Arrhythmia	10 (33.3%)	8 (100.0%)	1 (25.0%)	17 (37.8%)	0.005*

* Statistical significance ($p < 0.05$); BP: blood pressure; GCS: Glasgow Coma Scale; HTN: Hypertension.

DISCUSSION

Hypothermia is a medical emergency with potentially life-threatening consequences if not promptly treated. This retrospective analysis from the largest emergency hospital in North-Eastern Romania explored the characteristics of AH patients with adverse outcomes. The likelihood of an unfavorable prognosis is exacerbated by the presence of factors such as a reduced GCS, decreased SBP and DBP, metabolic acidosis, the presence of anemia, coagulation disorders, and the requirement for intravenous administration of inotropic or vasodilator medications. Recognizing the significance of these associated factors empowers healthcare practitioners to intervene at an early stage, potentially preventing the progression of the disease or minimizing its negative effects.

THE GLASGOW COMA SCORE

The GCS assessment is a critical tool in the field of emergency and critical care. Over time, several researchers have discovered the predictive significance of the GCS score in the management

of various types of clinical conditions, especially neurological diseases, such as trauma, acute brain injuries, acute stroke, bacterial meningitis, cerebral venous thrombosis, and even after cardiac arrest. Higher GCS score values were associated with a favorable prognosis, and low GCS score values were associated with higher short-term mortality rates [10–15]. Our study also demonstrates the importance of this score and its predictive power. In our study, the hypothermic patients with poor outcomes had lower GCS scores at admission, compared to patients whose evolution was favorable. It's important to note that certain patients in the study had varying blood ethanol concentrations, potentially affecting the calculation of the GCS score. Nevertheless, given the generally low mean concentrations upon admission, it is improbable that this influenced the GCS score significantly. Patients who showed improvement in their overall condition exhibited elevated serum ethanol levels compared to the other group. Nonetheless, this finding aligns with previous studies suggesting that mortality is more strongly associated with the presence of concurrent pathological conditions rather than the presence of ethanol in the bloodstream [16].

The results of our study coincide with the data currently available in the literature, regarding the evolution of patients with both accidental hypothermia and those with therapeutically induced hypothermia after cardiac arrest [6]. The GCS assessment is a fundamental and indispensable tool, and its simplicity make it an essential component of modern medicine, being able to predict the unfavorable evolution of patients with accidental hypothermia.

BLOOD PRESSURE VALUES

Maintaining adequate SBP is crucial for organ perfusion, ensuring vital organs receive enough oxygen and nutrients. Low SBP indicates a higher risk of death. The therapeutic goal for these patients is to sustain sufficient cardiac output, achieved through inotropic substance administration. However, short-term inotrope use was linked to further BP drop, tachycardia, increased oxygen consumption, and the inevitable occurrence of myocardial ischemia, atrial, and ventricular arrhythmias [17]. Oyetunji *et al.* focused on determining the hypotension threshold (50–150 mmHg) that most accurately predicted death in elderly patients without AH. They noted that for individuals under 65 years old, 117 mmHg could be the best indicator of mortality [18,19]. Several other studies highlight that SBP below 90 mmHg is a mortality risk factor in geriatric trauma patients, with a direct correlation between low SBP and increased mortality [20–22].

Moreover, in one study, patients with therapeutic hypothermia after cardiac arrest, in whom lower values of SBP were found, had worse neurological results than patients in whom systolic blood pressure was over 100 mmHg [23]. Our study proves that patients with AH and negative outcomes had a mean SBP below 117 mmHg, while those with positive results had higher SBP values. In both cases, low SBP values were associated with decreased DBP.

HEMOGLOBIN LEVELS

Patients with adverse outcomes in our study showed low hemoglobin levels, averaging 10.9 g/dl. Existing literature links anemia to disability, diminished physical performance, and muscle strength in the elderly, possibly explaining AH occurrence in our examined patients [24]. These factors make household chores challenging for the elderly, particularly relevant as many in our country still rely on wood-burning heaters in cold seasons, which demand physical strength to ensure adequate room temperature. The significant number of patients living alone further contributes to AH development, leading to an unfavorable prognosis.

Our study establishes an association between anemia and adverse outcomes. *Chaves et al.* linked mortality to hemoglobin levels below 11.0 g/dl in elderly women [24]. Another study found a strong connection between anemia and increased risk of all-cause hospitalization, hospitalization due to cardiovascular disorders, and all-cause mortality [24]. It activates the sympathetic nervous system, leading to tachycardia. Elevating cardiac oxygen demand, potentially causing myocardial ischemia, will alter left ventricular systolic function [25]. Such disruptions can cascade into compromised oxygen delivery, vital organ perfusion, and, if not effectively managed, result in the patient's death.

COAGULATION DISORDERS

Patients admitted with AH and unfavorable prognosis exhibited a higher occurrence of coagulopathies when compared to the control group. The data available in the existing literature support the findings of our study. The occurrence of coagulopathy in hypothermia cases is linked to

increased mortality rates [25]. The impact of hypothermia on coagulopathy is firmly established, with various documented mechanisms influencing hemostasis: diminished platelet activity, impaired clotting factor function, and increased fibrinolysis [6].

pH VALUES

In the present study, low pH level was also a factor associated with negative outcomes. This result is consistent with data present in the published literature to date [26]. Acidosis reflects a profound disturbance of the cellular environment, the heterostatic adaptation of the acid-base balance, and therefore the foundation of any physiological process [27]. The adverse cardiovascular consequences of metabolic acidosis encompass diminished myocardial contractility and cardiac output, lowered renal and hepatic blood flow, vasodilatation, leading to hypotension, bradycardia, and an elevated risk of ventricular arrhythmias. Furthermore, acidosis plays a role in the onset of coagulation disorders, also associated with increased mortality [28].

LIMITATIONS

This study has several limitations to consider. Its retrospective nature as a cohort study is a notable limitation, the small group of patients included, and the single-center design study are important limitations that should be acknowledged. Treatment and intervention decisions were made on an individual basis by each physician, which introduces the potential for these decisions to have influenced the prognosis. Moreover, the analysis was based on GCS values recorded solely in the emergency department. It would have been advantageous to include subsequent GCS measurements after the patients left the emergency department, as they could have shown an improved score over time. Due to the design of the study, the available information was limited, making it difficult to measure the duration of hypothermia. It is crucial to comprehend the differences between prolonged hypothermia and a brief, isolated episode of hypothermia for proper management and intervention. Regarding the observed association between hypothermia and adverse outcomes, it is important to emphasize that our results do not establish causation. In this database, mortality was defined as encompassing all causes, and the specific pathophysiological plausible reasons for death remain undisclosed.

Despite these limitations, our study underlies the need for future research to paint a more complete picture of this critical issue.

CONCLUSIONS

The factors associated with an unfavorable prognosis of patients with AH identified in this study, such as reduced GCS score, diminished SBP, decreased bicarbonate, and hemoglobin levels, as well as the presence of coagulation disorders and the administration of inotrope or vasopressor medications, are the same with those published by the literature. Understanding factors linked to a negative prognosis is crucial for managing patients with this condition.

Introducere: Hipotermia accidentală prezintă un risc semnificativ de mortalitate, chiar și la persoanele cu o stare de sănătate bună. Recunoaşterea precoce a unor factori asociaţi cu un prognostic favorabil poate salva mai multe vieţi.

Metode: Studiul de față este un studiu pilot, retrospectiv, efectuat în cel mai mare spital de urgenţe din nord estul României, și a inclus toți pacienții cu hipotermie accidentală (temperatură corporală sub 35°C), spitalizați și tratați între ianuarie 2019 și decembrie 2022.

Rezultate: Un număr de 104 pacienți cu hipotermie accidentală au fost incluși în studiu, dintre care 90 de pacienți au avut date colectate și analizate statistic. Parametrii asociaţi cu un prognostic negativ au fost: un scor GCS redus (p=0,024), tensiunea arterială sistolică și diastolică scăzută (p=0,007, respectiv, 0,013), scăderea nivelului de bicarbonat (p=0,043) și a hemoglobinei (p=0,002), prezența tulburărilor de coagulare (p=0,007), precum și necesitatea administrării de medicamente inotrope sau vasopresoare (p=0,04).

Concluzii: În acest studiu pilot retrospectiv efectuat la pacienţii cu hipotermie accidentală, prognosticul negativ a fost asociat cu o serie de factori clinici, biologici şi terapeutici care pot fi uşor de evidenţiat în practica clinică. Recunoaşterea acestor parametri asociaţi cu un prognostic nefavorabil în hipotermia accidentală poate permite intervenirea într-un stadiu incipient pentru a salva mai multe vieţi.

Correspondence: to: Paula Cristina Morariu, PhD student, Medical Clinic, "Sfântul Spiridon" Emergency Hospital 700111 Iasi, Romania
Email: adascalitei.paula-cristina@d.umfiasi.ro

Acknowledgments: The authors would like to thank the Statistical Unit of "Sfântul Spiridon" Emergency Clinical Hospital for providing institutional access and assistance in developing this study.

Declaration of interest: The authors declare that there are no conflicts of interest.

REFERENCES

1. JURKOVICH GJ. Environmental Cold-Induced Injury. Surgical Clinics of North America. 2007;**87**(1):247–67.
2. PAAL P, PASQUIER M, DAROCHA T, LECHNER R, KOSINSKI S, WALLNER B, *et al.* Accidental Hypothermia: 2021 Update. International Journal of Environmental Research and Public Health, 2022.
3. SANFILIPPO F, LA VIA L, LANZAFAME B, DEZIO V, BUSALACCHI D, MESSINA A, *et al.* Targeted Temperature Management after Cardiac Arrest: A Systematic Review and Meta-Analysis with Trial Sequential Analysis. J Clin Med. 2021;**10**(17):3943.
4. KURISU K, YENARI MA. Therapeutic hypothermia for ischemic stroke; pathophysiology and future promise. Neuropharmacology. 2018;**134**:302–9.
5. NEDELEA PL, MANOLESCU E, CIUMANGHEL AI, CONSTANTIN M, HAUTA A, SIRBU O, *et al.* The Beginning of an ECLS Center: First Successful ECPR in an Emergency Department in Romania—Case-Based Review. Journal of Clinical Medicine. 2023,**12**.
6. AZARKANE M, RIJNHOUT TWH, VAN MERWIJK IAL, TROMP TN, TAN ECTH. Impact of accidental hypothermia in trauma patients: A retrospective cohort study. Injury. 2023.
7. RUMBUS Z, MATICS R, HEGYI P, ZSIBORAS C, SZABO I, ILLES A, *et al.* Fever Is Associated with Reduced, Hypothermia with Increased Mortality in Septic Patients: A Meta-Analysis of Clinical Trials. 2017;**12**(1):e0170152.
8. RAMGOPAL S, HORVAT CM, ADLER MD. Association of triage hypothermia with in-hospital mortality among patients in the emergency department with suspected sepsis. J Crit Care. 2020;**60**:27–31.
9. FATTEH N, SUTHERLAND GE, SANTOS RG, ZEIDAN R, GASTESI AP, NARANJO CD. Association of hypothermia with increased mortality rate in SARS-CoV-2 infection. International Journal of Infectious Diseases. 202;**108**:167–70.
10. MAHDIAN M, FAZEL MR, FAKHARIAN E, AKBARI H, MAHDIAN S. Cerebral state index versus Glasgow coma scale as a predictor for in-hospital mortality in brain-injured patients. Chinese Journal of Traumatology - English Edition. 2014;**17**(4):220–4.
11. KOROLEVA E, ALIFIROVA V, KAZAKOV S, PLOTNIKOV D, NIKITINA M. Serum S100B protein and Glasgow Coma Scale as predictive markers of the survival rate in acute ischemic stroke. J Neurol Sci. 2021;**429**:118767.
12. GUPTA S, SONI R, DHULL P, SOMASEKHARAN M, SREEN A. Glasgow Coma Scale ≤ 12 at Admission is a Predictor of Poor Functional Outcome (mRS 2–6) at One Year in Patients with Cerebral Venous Thrombosis. Journal of Stroke and Cerebrovascular Diseases. 2021;**30**(7).
13. NADOLNY K, BUJAK K, OBREMSKA M, ZYSKO D, STERLINSKI M, SZARPAK L, *et al.* Glasgow Coma Scale score of more than four on admission predicts in-hospital survival in patients after out-of-hospital cardiac arrest. American Journal of Emergency Medicine. 2021;**42**:90–4.
14. VAN ETTEKOVEN CN, BROUWER MC, WIJDICKS EFM, VAN DE BEEK D. A comparison of the four score and the Glasgow Coma Scale in predicting outcome of bacterial meningitis patients. J Neurol Sci. 2017;**381**:70–1.
15. JIANG D, CHEN T, YUAN X, SHEN Y, HUANG Z. Predictive value of the Trauma Rating Index in Age, Glasgow Coma Scale, Respiratory rate and Systolic blood pressure score (TRIAGES) and Revised Trauma Score (RTS) for the short-term mortality of patients with isolated traumatic brain injury: A retrospective study. American Journal of Emergency Medicine. 2023;**71**:175–81.
16. LOPPNOW G, WILSON L. Effects of ethanol on systemic hemodynamics in a porcine model of accidental hypotermia. Am. J. Emerg. Med.2015; **33**(10):1414-1419.
17. GHEORGHIADE M, VADUGANATHAN M, AMBROSY A, BÖHM M, CAMPIA U, CLELAND JGF, *et al.* Current management and future directions for the treatment of patients hospitalized for heart failure with low blood pressure. Heart Fail Rev. 2013;**18**(2):107–22.
18. OYETUNJI TA. Redefining Hypotension in the Elderly. Archives of Surgery. 2011;**146**(7):865.
19. ÉMOND M, LACHANCE-PERREAULT D, BOUCHER V, CARMICHAEL PH, TURGEON J, BROUSSEAU AA, *et al.* The impact of post-intubation hypotension on length of stay and mortality in adult and geriatric patients: a cohort study. Canadian Journal of Emergency Medicine. 2022;**24**(5):509–14.

20. TAYLOR MD, KATHLEEN TRACY J, MEYER W, PASQUALE M, NAPOLITANO LM. Trauma in the Elderly: Intensive Care Unit Resource Use and Outcome Background: As the population ages. 2002; http://journals.lww.com/jtrauma.
21. GROSSMAN MD, MILLER D, SCAFF DW, ARCONA S. When Is an Elder Old? Effect of Preexisting Conditions on Mortality in Geriatric Trauma. 2002; http://journals.lww.com/jtrauma.
22. LUSTENBERGER T, INABA K, SCHNÜRIGER B, BARMPARAS G, EBERLE BM, LAM L, *et al.* Gunshot injuries in the elderly: Patterns and outcomes. A national trauma databank analysis. World J Surg. 2011;**35**(3):528–34.
23. PERMAN S, GROSSESTREUER A, LEARY M, NAPOLI A, BEYLIN M, ABELLA B, *et al.* Association between initial blood pressure meaasurements and outcome in post-cardiac arrest patients treated with therapeutic hypothermia. Resuscitation. 2012,e24-e123.
24. DUKE M, ABELMANN WH. The Hemodynamic Response to Chronic Anemia. Circulation. 1969;**39**(4):503–15.
25. ROHRER M, NATALE A, MLT B. Effect of hypothermia on the coagulation cascade. Crit Care Med. 1992;**20**(10):1402–5.
26. TAKAUJI S, HIFUMI T, SAIJO Y, YOKOBORI S, KANDA J, KONDO Y, *et al.* Accidental Hypothermia: Factors Related to a Prolonged Hospital Stay – A Nationwide Observational Study in Japan. Am J Emerg Med 2021, **47**, 169–175.
27. WERNLY B, HERAMVAND N, MASYUK M, REZAR R, BRUNO R.R, KELM M, *et al.* Acidosis Predicts Mortality Independently from Hyperlactatemia in Patients with Sepsis. Eur J Intern Med 2020, **76**, 76–81.
28. MIKHAIL J. The Trauma Triad of Death: Hypothermia, Acidosis, and Coagulopathy. AACN Adv Crit Care 1999, **10**, 85–94.

Received 12th December 2023