

# Herzanästhesie Österreich

## *Herzensschicksal*

## Hypothermie CPR - Kalt und tot?



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# Resuscitation from accidental hypothermia of 13.7°C with circulatory arrest

Mads Gilbert, Rolf Busund, Arne Skagseth, Paul Åge Nilsen, Jan P Solbø

**In a victim of very deep accidental hypothermia, 9 h of resuscitation and stabilisation led to good physical and mental recovery. This potential outcome should be borne in mind for all such victims.**

and winched her into the helicopter. CPR and positive-pressure manual ventilation bag-to-tube was continued during the 1 h flight to Tromsø University Hospital. They arrived at 2110 h.

Gilbert et al. Lancet. 2000

# Sequela-free long-term survival of a 65-year-old woman after 8 hours and 40 minutes of cardiac arrest from deep accidental hypothermia

Marie Meyer, MD,<sup>a</sup> Nathalie Pelurson, MD,<sup>b</sup> Ebrahim Khabiri, MD,<sup>c</sup> Nils Siegenthaler, MD,<sup>d</sup> and Beat H. Walpoth, MD,<sup>c</sup> Geneva, Switzerland, and Embrun, France

Meyer et al. J Thorac Cardiovasc Surg. 2014



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Contents lists available at [ScienceDirect](#)

Cryobiology

journal homepage: [www.elsevier.com/locate/ycryo](http://www.elsevier.com/locate/ycryo)



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Survival of a cardiac arrested victim with hypothermia despite severely elevated serum potassium (9.0 mmol/L)



Pasquier et al. Cryobiology. 2017

# Beobachteter Stillstand



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Available online at [www.sciencedirect.com](http://www.sciencedirect.com)

## Resuscitation

journal homepage: [www.elsevier.com/locate/resuscitation](http://www.elsevier.com/locate/resuscitation)



EUROPEAN  
RESUSCITATION  
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### **Clinical characteristics and outcomes of witnessed hypothermic cardiac arrest: A systematic review on rescue collapse**

- Am Unfallort Temperatur  $23,9 \pm 2,7^\circ\text{C}$ , nie  $>30^\circ\text{C}$
- Am Unfallort GCS 5 (3-7), nie  $>10$
- Initialer Rhythmus VF in 64% der Fälle, Asystolie in 30%.
- CPR Dauer 132 (71-180)
- Bei Krankenhausaufnahme Kalium  $4,3 \pm 1,5$  mEq/L, Laktat  $10,4 \pm 5,4$  mmol/L und pH-Wert  $7,0 \pm 0,2$ .

Survival rate (missing = 4), n (%)	153/210 (73%)
Survival rate according to the rhythm (missing = 106), n (%)	
	Ventricular fibrillation / pulseless ventricular tachycardia 57/68 (84)
	Asystole 23/33 (70)
	Pulseless electrical activity 3/7 (43)
Neurological outcome of survivors (missing = 38), n (%)	
	Good (CPC = 1-2) <sup>b</sup> 102/115 (89)

# Unbeobachteter Stillstand

MAIN TEXT ARTICLE



## Outcomes of patients suffering unwitnessed hypothermic cardiac arrest rewarmed with extracorporeal life support: A systematic review

Variable (units; number of patients with data)	Overall (n = 221)	Survivors (n = 60)	Non-survivors (n = 161)	P (survival)	CPC 1-2 (n = 50)	CPC 3-5 (n = 171)	P (CPC)
Temperature °C (221)	24.3 ± 3.7	23 ± 2.9	24.7 ± 3.9	.004	22.7 ± 2.7	24.7 ± 3.9	<.001
Potassium mmol/L (210)	5.0 [3.7-7.1]	3.7 [2.9-4.6]	5.8 [4.2-8]	<.001	3.7 [3.2-4.5]	5.7 [4-7.8]	<.001
pH (187)	6.76 ± 0.3	6.89 ± 0.2	6.71 ± 0.3	<.001	6.91 ± 0.2	6.71 ± 0.3	<.001
Lactate mmol/L (89)	14.8 ± 6.6	11 ± 3.6	16.1 ± 6.9	.001	10.9 ± 3.8	15.9 ± 6.9	.003
Initial rhythm (213)							
Asystole	138 (65.1%)	28 (48.3%)	110 (71%)	<.001	22 (45.8%)	116 (70.3%)	<.001
PEA	19 (9%)	12 (20.7%)	7 (4.5%)		10 (20.8%)	9 (5.4%)	
VF	56 (26.4%)	18 (31%)	38 (24.5%)		16 (33.3%)	40 (24.2%)	
CPR duration min (206)	120 [90-163]	105 [75-140]	120 [95-168]	.003	105 [71-144]	120 [93-165]	.02

Adapted from Podsiadło et al. Artif Organs. 2021

**27 % der Patienten überlebten, davon 83 % neurologisch intakt.**

# Stillstandmechanismus

Variable (units; number of patients with data)	Overall (n = 221)	Survivors (n = 60)	Non-survivors (n = 161)	P (survival)	CPC 1-2 (n = 50)	CPC 3-5 (n = 171)	P (CPC)
Mechanism of cooling (217)							
Exposure	68 (31.3%)	30 (51.7%)	38 (23.9%)	<.001	28 (57.1%)	40 (23.8%)	<.001
Immersion	15 (6.9%)	9 (15.5%)	6 (3.8%)		9 (18.4%)	6 (3.6%)	
Submersion	95 (43.8%)	19 (32.8%)	76 (47.8%)		12 (24.5%)	83 (49.4%)	
Avalanche	39 (17%)	0	39 (24.5%)		0	39 (23.2%)	
Non-asphyxia-related mechanism (exposure + immersion) (217)	83 (38.2%)	39 (67.2%)	44 (27.7%)	<.001	37 (75.5%)	46 (27.4%)	<.001

Adapted from Podsiadło et al. Outcomes of patients suffering unwitnessed hypothermic CA rewarmed with ECLS. Artif Organs. 2021



# INTERNATIONAL HYPOTHERMIA REGISTRY

Variable	Survivors <i>n</i> = 26 <i>Data available</i>		Non-survivors <i>n</i> = 47 <i>Data available</i>		<i>P</i>
<i>N</i>					
Temperature at hospital arrival (median [IQR])	<i>n</i> = 26	24.9 [22.2, 25.5]	<i>n</i> = 47	25.6 [23.0, 28.1]	0.14
ECG at hospital arrival	<i>n</i> = 24		<i>n</i> = 38		0.35
- asystole		<i>n</i> = 1		<i>n</i> = 16	
- ventricular fibrillation		<i>n</i> = 10		<i>n</i> = 19	
- PEA		<i>n</i> = 4		<i>n</i> = 2	
- Sinus		<i>n</i> = 9		<i>n</i> = 1	
Witnessed cardiac arrest	<i>n</i> = 24	<i>n</i> = 17 (71%)	<i>n</i> = 27	<i>n</i> = 8 (30%)	0.005
Asphyxia confirmed	<i>n</i> = 22	<i>n</i> = 5 (23%)	<i>n</i> = 39	<i>n</i> = 19 (49%)	0.059
ROSC before rewarming	<i>n</i> = 26	<i>n</i> = 9 (35%)	<i>n</i> = 42	<i>n</i> = 3 (7%)	0.007
Successful defibrillation	<i>n</i> = 8	<i>n</i> = 4 (50%)	<i>n</i> = 10	<i>n</i> = 1 (10%)	0.12
Major trauma	<i>n</i> = 26	<i>n</i> = 11 (42%)	<i>n</i> = 38	<i>n</i> = 11 (29%)	0.30
Pre-rewarming lab findings					
- Ph	<i>n</i> = 17	6.96 ±14	<i>n</i> = 33	6.85 ± 0.39	0.30
- Potassium, mMol/L	<i>n</i> = 22	3.5 ± 0.9	<i>n</i> = 37	6.5 ± 2.5	0.001
- Lactate, mMol/L	<i>n</i> = 19	11.1 ± 5.2	<i>n</i> = 20	16.2 ± 5.1	0.003

Adapted from Walpoth et al. Hypothermic Cardiac Arrest - Retrospective cohort study from the International Hypothermia Registry. Resuscitation. 2021

# Initiales Lactat



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Contents lists available at [ScienceDirect](#)

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: [www.jcvaonline.com](http://www.jcvaonline.com)



Original Article

## Prognostic Factors for Nonasphyxia-Related Cardiac Arrest Patients Undergoing Extracorporeal Rewarming - HELP Registry Study



**53 % survival, davon 94 % CPC 1-2.**

**“Initial lactate concentration (<11.9 mmol/L) proved to be the strongest predictor of both survival and a lack of neurologic deficit.”**

### Prognostic Factors of Survival

Variable	OR	95% CI	p
<b>Univariate analysis</b>			
Age	0.959	(0.93-0.99)	<b>0.01*</b>
Female	1.909	(0.535-6.815)	0.32
Tc	0.853	(0.20-1.011)	0.068
Rescue collapse	2.143	(0.893-5.144)	0.088
Use of MCCD	0.895	(0.225-3.555)	0.875
Asystole	1.149	(0.471-2.799)	0.76
PEA	0.161	(0.018-1.431)	0.1
VF/pVT	1.319	(0.57-3.055)	0.52
CPR time	0.995	(0.99-1)	0.06
pH	8.343	(1.094-63.617)	<b>0.04*</b>
PaCO <sub>2</sub>	1.002	(0.98-1.025)	0.83
BE	1.04	(0.986-1.098)	0.15
Initial glycemia	0.987	(0.927-1.05)	0.67
Initial potassium	0.743	(0.552-1)	0.05
Initial lactate	0.882	(0.8-0.968)	<b>0.008*</b>
<b>Multivariate Analysis</b>			
Age	0.957	(0.924-0.991)	<b>0.014*</b>
Initial lactate	0.871	(0.789-0.961)	<b>0.006*</b>

Darocho et al. J Cardiothorac Vasc Anesth. 2020 Feb

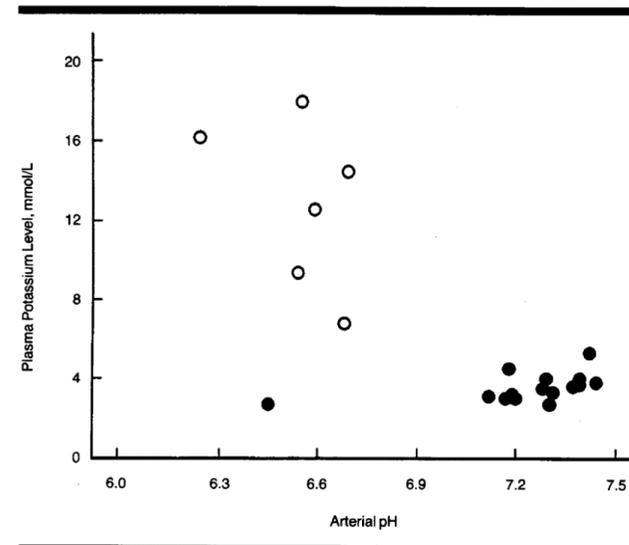
# Initiales Kalium

Allgemein gilt  $K > 12 \text{ mmol/L}$  bei AH (Lawine  $> 8 \text{ mmol/L}$ ) als Indikator für schlechtes Outcome



## Hyperkalemia

A Prognostic Factor During Acute Severe Hypothermia



Plasma potassium and arterial pH were measured in hypothermic victims of snow avalanches (group A: open circles) and in patients with hypothermia following acute drug intoxication and/or cold exposure (group B: closed circles). No correlation was found in group A ( $r = .31$ ) or in group B ( $r = .58$ ) between plasma potassium and pH.

Schaller et al. JAMA. 1990



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# Resuscitation

journal homepage: [www.elsevier.com/locate/resuscitation](https://www.elsevier.com/locate/resuscitation)



Review

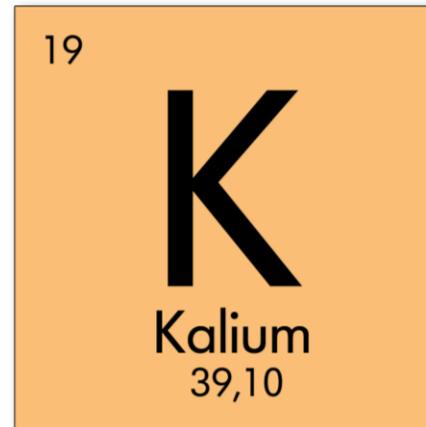
## The impact of hypothermia on serum potassium concentration: A systematic review



Sarah Buse<sup>a</sup>, Marc Blancher<sup>b</sup>, Damien Viglino<sup>b</sup>, Mathieu Pasquier<sup>c</sup>, Maxime Maignan<sup>b</sup>, Pierre Bouzat<sup>d</sup>, Thorsten Annecke<sup>a</sup>, Guillaume Debaty<sup>b,\*</sup>

### Milde Hypothermie → Hypokaliämie

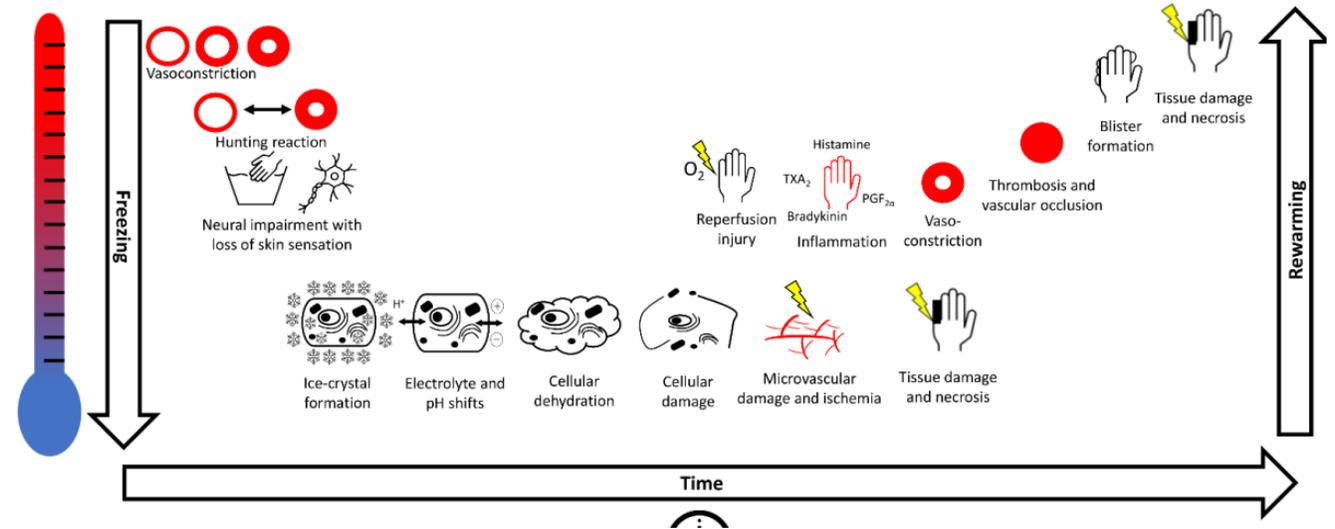
- Intrazellulärer shift und Liver pooling
- Membran stabilisierender Effekt
  - Respiratorische Alkalose
  - Beta2 adrenerge Stimulation
  - Kälte diurese und Tubulusdysfunktion
  - Stoffwechsel ↓



### Tiefe Hyperthermie → Hyperkaliämie

- Intrazellulärer shift ↓
- Passiver Efflux ↑
- Zellyse

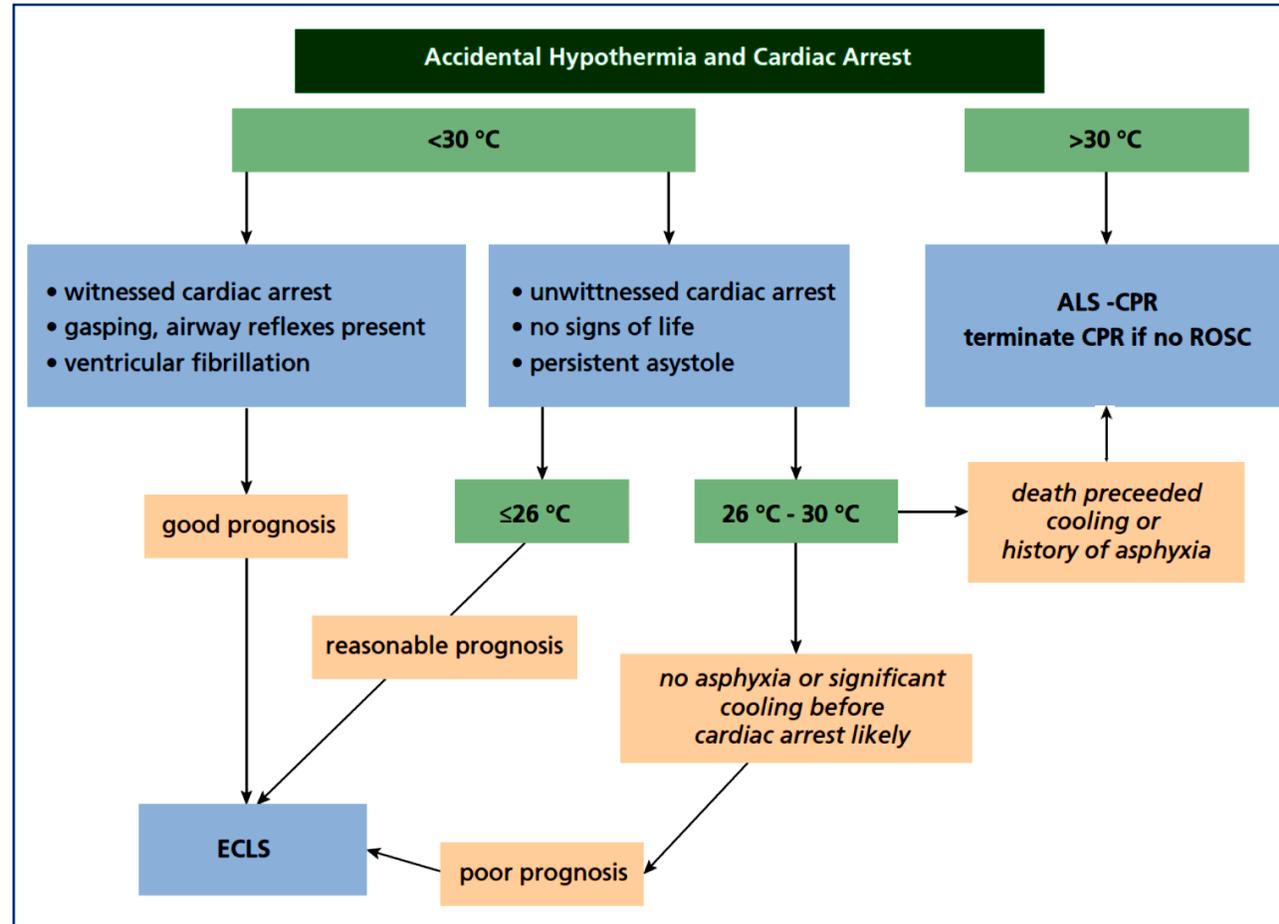
# Lokale Erfrierungen



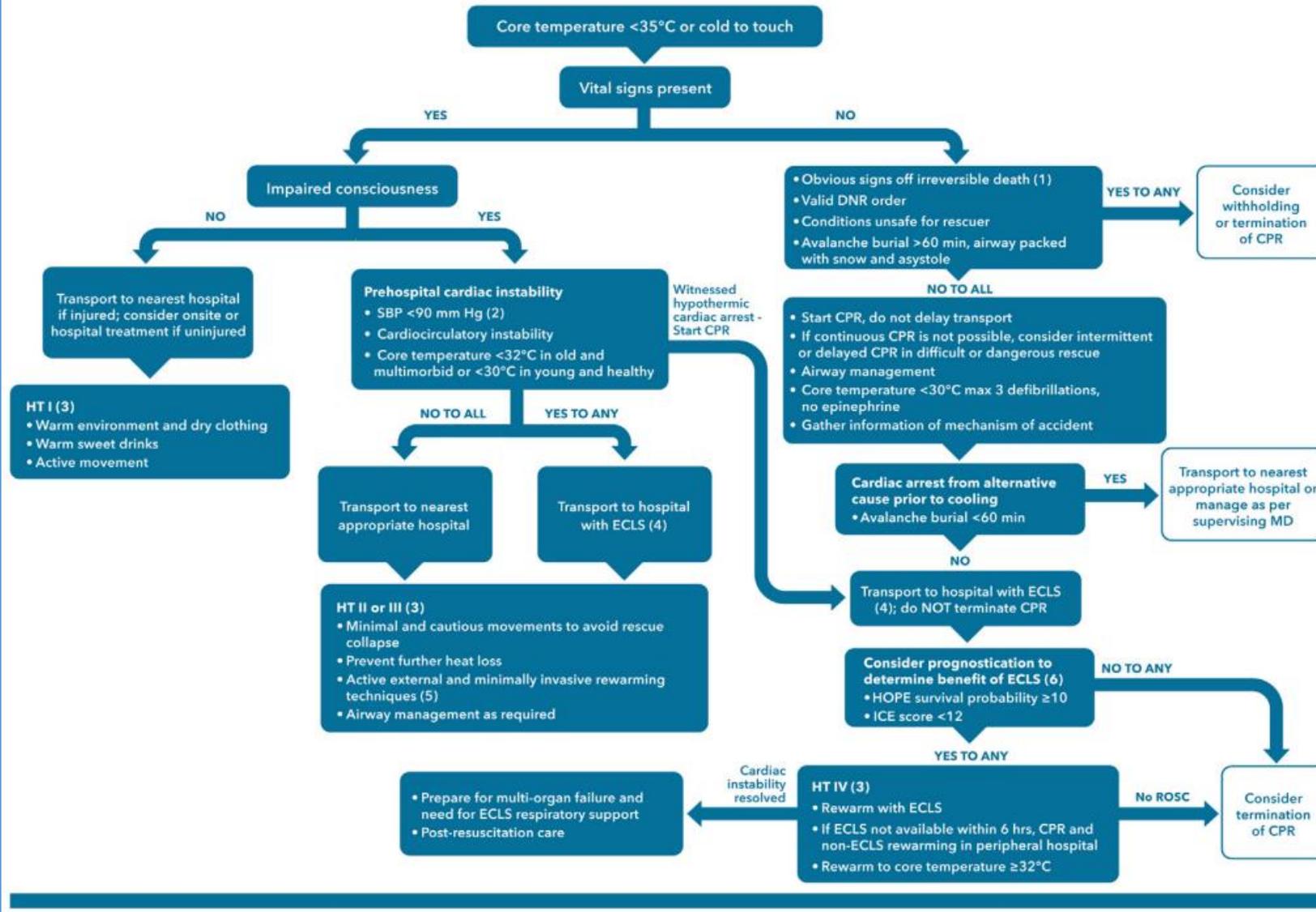
Regli et al. Long-Term Sequelae of Frostbite-A Scoping Review. Int J Environ Res Public Health. 2021

Bei Asphyxieanamnese kann ein K ↑ hinweisend für Diagnose „Todeseintritt vor Abkühlung“ sein

# Initiale Temperatur



# ACCIDENTAL HYPOTHERMIA





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## Resuscitation

journal homepage: [www.elsevier.com/locate/resuscitation](http://www.elsevier.com/locate/resuscitation)



Clinical paper

### Hypothermia outcome prediction after extracorporeal life support for hypothermic cardiac arrest patients: The HOPE score<sup>☆</sup>

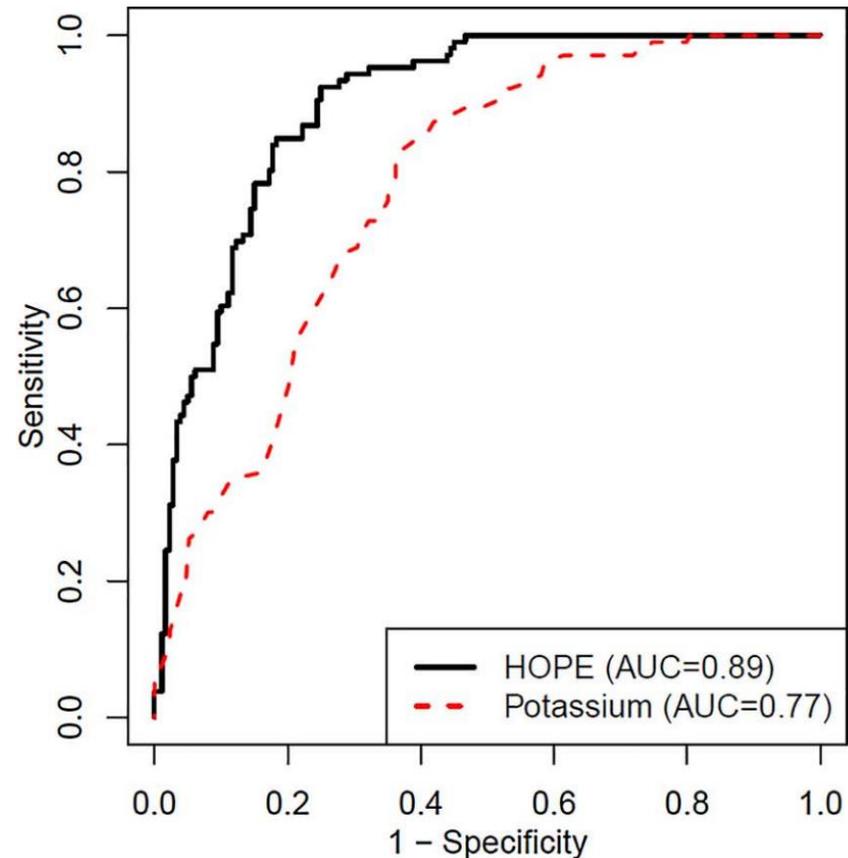


Mathieu Pasquier<sup>a,\*</sup>, Olivier Hugli<sup>a</sup>, Peter Paal<sup>b</sup>, Tomasz Darocha<sup>c</sup>, Marc Blancher<sup>d</sup>, Paul Husby<sup>e</sup>, Tom Silfvast<sup>f</sup>, Pierre-Nicolas Carron<sup>a</sup>, Valentin Rousson<sup>g</sup>

Bestimmung der Überlebenswahrscheinlichkeit nach Wiedererwärmung hypothermer CA Patienten auf Grundlage von:

- Alter
- Geschlecht
- Temperatur
- Serumkalium
- CPR Dauer
- Abkühlungsmechanismus

# HOPE Score



Potassium	>12	≤12	
	5	58	37
	Rewarming not indicated	Futile rewarming (non-survivors)	Successfull rewarming (survivors)
	32	31	37
HOPE	< 0.10	≥ 0.10	



Hypothermia Outcome Prediction after ECLS

## Hypothermia Outcome Prediction after Extracorporeal Life Support for Hypothermic Cardiac Arrest Patients. Estimation of the survival probability using HOPE.



HOPE is the result of an international collaborative project initiated and led by the Emergency Department of the University Hospital of Lausanne, Switzerland.

HOPE provides a prediction of the survival probability in hypothermic cardiac arrest patients undergoing Extra-Corporeal Life Support (ECLS) rewarming. The survival probabilities range from 0% to 100% chance of survival to hospital discharge.

A cutoff of 10% to decide which hypothermic patients in cardiac arrest would benefit or not from ECLS rewarming was evaluated in an external validation study. The negative predictive value of a HOPE probability <10% was of 97%, and the AUC under the ROC curve was of 0.825 which suggest excellent discrimination.

HOPE should not be considered a substitute for clinical judgment or assessment. Of note, one is of course free to use a different cut-off than the proposed threshold of 10% for different subgroups of the population (e.g. for children). The proportion of avalanche victims was low in the validation HOPE study (4%). We recommend to use HOPE cautiously in this specific group of patients.

Estimates are desirable if variables are not known (e.g. age, CPR duration and temperature).

Age (in years)

Sex  Male  Female

Hypothermia  with asphyxia (head fully covered by water or snow) AND in cardiac arrest at extrication  
 without asphyxia (immersion, outdoor or indoor cold exposure)

 CPR duration (min)

 Serum Potassium (mmol/L)

Temperature scale  Celsius  Fahrenheit

 Temperature



Hypothermia Outcome Prediction after ECLS

## Hypothermia Outcome Prediction after Extracorporeal Life Support for Hypothermic Cardiac Arrest Patients. Estimation of the survival probability using HOPE.

The HOPE survival probability is: 22 %.



The submitted data were:

Age: 50, sex: male, hypothermia without asphyxia, CPR duration: 180 min, potassium: 5.7 mmol/l, temperature: 24 Celsius



Hypothermia Outcome Prediction after ECLS

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Estimates are desirable if variables are not known (e.g. age, CPR duration and temperature).

Age (in years)

Sex  Male  Female

Hypothermia  with asphyxia (head fully covered by water or snow) AND in cardiac arrest at extrication  
 without asphyxia (immersion, outdoor or indoor cold exposure)

CPR duration (min)

Serum Potassium (mmol/L)

Temperature scale  Celsius  Fahrenheit

Temperature



Hypothermia Outcome Prediction after ECLS

## Hypothermia Outcome Prediction after Extracorporeal Life Support for Hypothermic Cardiac Arrest Patients. Estimation of the survival probability using HOPE.

The HOPE survival probability is: 18 %.



The submitted data were:

Age: 50, sex: male, hypothermia without asphyxia, CPR duration: 240 min, potassium: 5.7 mmol/l, temperature: 24 Celsius

# Conclusio

- CPR von akzidentell hypothermen Patienten ist keine Routine
- Selbst ein nicht-beobachteter hypothermer Stillstand kann mit einem gutem Outcome einhergehen
- Asystolie tritt in tiefer Hypothermie häufig auf und kann mit einem guten Outcome einhergehen
- Je kälter desto eher ECLS
- Ein Parameter alleine darf die Therapie nicht entscheiden
- Scores können in der Entscheidungsfindung (ECLS ja/nein) helfen