Accidental Hypothermia and intermittent CPR

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European Resuscitation Council ALS Education and Science Committee
Research Lead- International Commission for Mountain Emergency Medicine

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Pathophysiology
Diagnosis
Therapy

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Defintion

Accidental hypothermia core temperature unintentionally <35° C (95° F)

Brown D, et al. N Engl J Med. 2012 Nov 15;367(20):1930-8. doi: 10.1056/NEJMra1114208.
Hislop LJ, et al. *BMJ 1995*, 311, 725.
Darocha T, et al. J Cardiothorac Vasc Anesth 2019 in press, https://doi.org/10.1053/j.jvca.2019.07.152

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https://humanorigins.si.edu/evidence/human-fossils/species/homo-sapiens

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Cheddar Man

10.000 BC http://www.independent.co.uk

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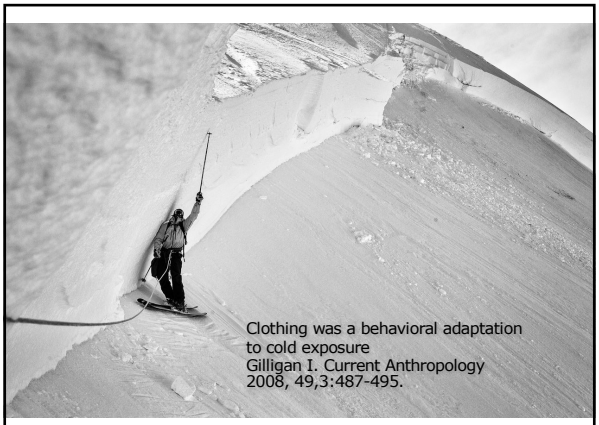

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Lowest AH core temperature

- 2-year-old boy
- Lowest core temperature 11.8° C
- Unwitnessed asystolic cardiac arrest
- CPR 135min
- 22hrs ECMO
- At hospital discharge CPC 1
- No mental impairment after five years

Darocha T, et al. J Cardiothorac Vasc Anesth 2020 Feb;34(2):365-371. doi: 10.1053/j.jvca.2019.07.152.

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Longest submersion

- 2.5-year-old, submersion in cold water for at least **66 min**, **19° C**, **ECLS** rewarming, **full recovery**
  Bolte RG, et al. JAMA 1988;260(3):377–9
- 7-year-old child, submersion in icy water for at least **83 min**, CPR for 64 min, **13.8° C**, K+ 11.3 mmol L-1, **ECLS** rewarming, **full recovery**
  Romlin BS, et al. Crit Care Med 2015;43:e521–5.

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Diminished O_2 metabolism

O_2-consumption 7%↓ /1° C↓

Lexow K. Arctic Med Res 1991;50 Suppl 6:112-4.
Soar J, Paal P et al. Resuscitation 2010;81:1400-33.

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Hypothermic cardiac arrest can be survived exceptionally long

Severe accidental hypothermia: survival after 6 hours 30 minutes of cardiopulmonary resuscitation.

Lexow K. Arctic Med Res 1991;
50 Suppl 6:112-4.

Hypothermia before Hypoxia

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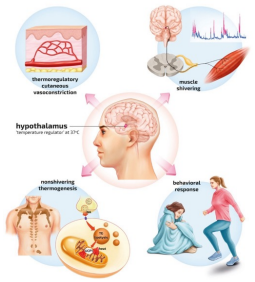
Thermoregulation



Paal P, et al. IJERPH 2021, in press.

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Acute hypothermia

Setting
- Hypothermia induced cardiac arrest

Pathophysiology
- Water immersion/snow burial
- Cold overwhelmes heat production
- Cooling before glucose depletion→ catecholamines/corticosteroids grossly stimulated, CPR
- **Glucose level supranormal**

Beiser DG et al. Resuscitation. 2009 Jun;80(6):624-30.
van den Berghe G et al. N Engl J Med. 2001 Nov 8;345(19):1359-67.
Skrifvars MB et al. Resuscitation. 2003 Dec;59(3):319-28.

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Subacute hypothermia

Setting
- Exhaustion, exposure to moderate cold
- Immersion in relatively warm water

Pathophysiology
- Moderate cold
- Cooling when glucose is depleted
- No spontaneous rewarming
- **Glucose level low**

Young A et al. Appl Physiol Nutr Metab 2007 Aug;32(4):793-8.

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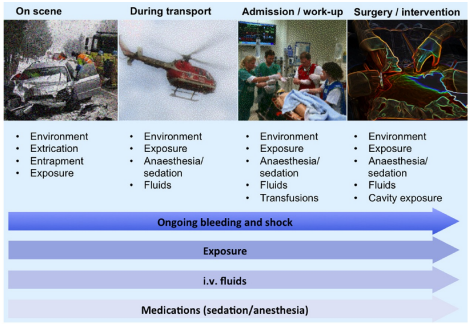
Involuntary cooling



Søreide K. Injury. 2014 Apr;45(4):647-54.

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Staging hypothermia

Stage	Clinical Findings	Core temperature (°C) (if available)
Hypothermia I (mild)	Conscious, shivering*	35-32°C
Hypothermia II (moderate)	Impaired consciousness*; may or may not be shivering	<32-28°C
Hypothermia III (severe)	Unconscious*; vital signs present	<28°C
Hypothermia IV (severe)	Apparent death; Vital signs absent	Variable**

Adapted from Paal 2016.

*Shivering or consciousness may be impaired by comorbid illness (e.g. trauma, brain disorders, toxins) or drugs (e.g. sedatives, opioids, muscle relaxants) independent of core temperature.

**Cardiac arrest can occur at earlier or later stages of hypothermia and some patients may still have vital signs at <24 °C

Soar J, et al. Lancet 2021, Oct 2;398(10307):1257-1268.

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Revised Swiss Staging

	Stage 1	Stage 2	Stage 3	Stage 4
Clinical findings[1]	"Alert" from AVPU	"Verbal" from AVPU	"Painful" or "Unconscious" from AVPU Vital signs present	"Unconscious" from AVPU **AND** No detectable vital signs[2]
Risk of cardiac arrest[3]	Low	Moderate	High	**Hypothermic cardiac arrest**
Oxygen	According to good clinical practice, (goal: SpO_2 > 94%)[4]	+	+	+
Carbohydrats	Warm sweet tea, sweet bars	Glucose i.v. / i.o.[5]	Glucose i.v. / i.o.[5]	-
Active movement	+	+[6]	-	-
Passive rewarming	+	+	+	+
Active rewarming	(+)	+	+	+
Cautious mobilization / horizontal transport if possible	-	+	+	-
Defibrillation pads		+	+	+
Intubation			to be considered	+
Hypothermia CPR				+
Defibrillation				+[7]

Musi M, et al Resuscitation 2021. May;162:182-187

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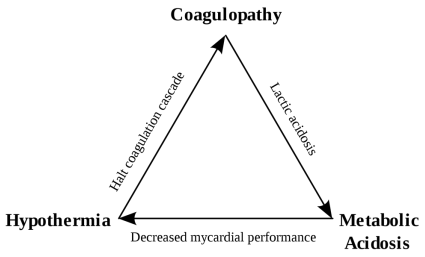
Deadly triad in trauma



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Blood loss

1° C cooling

- intraoperative bleeding 10-15%↑
- packed red blood cells transfusion 12%↑

Rajagopalan S et al. Anesthesiology 2008;108(1):71-7.

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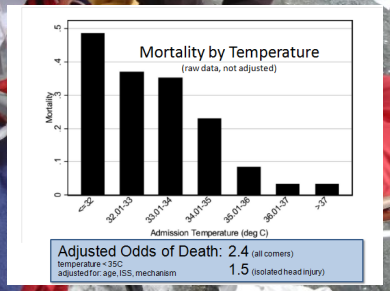
Admission hypothermia and outcome after major trauma



Wang HE, et al. Crit Care Med. 2005 Jun;33(6):1296-301.

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Sumann et al. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine (2020) 28:117
https://doi.org/10.1186/s13049-020-00790-1

Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine

REVIEW Open Access

Multiple trauma management in mountain environments - a scoping review

Evidence based guidelines of the International Commission for Mountain Emergency Medicine (ICAR MedCom). Intended for physicians and other advanced life support personnel

G. Sumann[1], D. Moens[2], B. Brink[3], M. Brodmann Maeder[4], M. Greene[5], M. Jacob[6], P. Koirala[7], K. Zafren[8,9], M. Ayala[10], M. Musi[11], K. Oshiro[12], A. Sheets[13], G. Strapazzon[14,15], D. Macias[16] and P. Paal[17*]

Sumann G, et al. Scand J Trauma Resusc Emerg Med 2020;28:117.

22

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Pre-hospital therapy

Splinting and immobilization→ bleeding↓
Ellerton J, Paal P et al. High Alt Med Biol. 2009 Winter;10(4):337-42.

Insulation and heating

- Avoid wind and wetness
- Warming pack
- Warm transport vehicle

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No faster rewarming with large chemical heat pads
Lundgren P, Henriksson O, Naredi P, Björnstig U. Scand J Trauma Resusc Emerg Med. 2011 Oct 21;19:59.

No difference whether wet clothes are removed or waterproof vapour barrier is provided
Henriksson O, Lundgren P, Kuklane K, Holmér I, Naredi P, Björnstig U. Prehosp Disaster Med 2012 Feb;27(1):53-8.

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Analgesia and anaesthesia

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Analgesia decreases thermoregulation

Analgesia & anaesthesia → vasodilatation & thermoregulation↓

Ketamine may be the least detrimental analgesic

Marland S, et al. CNS Neurosci Ther. 2013 Jun;19(6):381-9. doi: 10.1111/cns.12072.

Methoxyflurane, fentanyl lozenges

Prehosp Emerg Care. 2023;27(8):987-992. doi: 10.1080/10903127.2022.2107125. Epub 2022 Aug 12..

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Accidental Hypothermia Clinical Practice Guideline for British Columbia

Accidental Hypothermia – Evaluation, Triage & Management

Version 1.02: April 4, 2016
Written by: Dr. Doug Brown & BC Accidental Hypothermia Working Group

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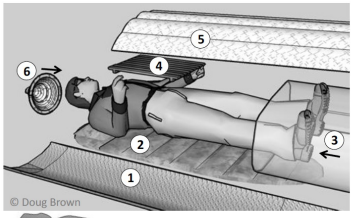
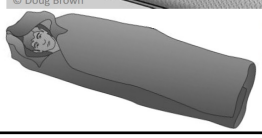
Minimally Invasive Rewarming- Hypothermia burrito



1. Outer wind & waterproof +/- reflective tarp (prehospital only)
2. Insulation or heating pad*
3. Replace wet clothes if practical, otherwise wrap patient in plastic
4. Forced air, chemical or electrical heating device(s)*
5. Insulating blanket
6. Insulate the head**



* To avoid burns, keep heating device temperatures <~40°C.
**If in cardiac arrest, do not apply heat to the head (allow warm oxygenated blood to rewarm the brain centrally).

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Cold Patient, Conscious

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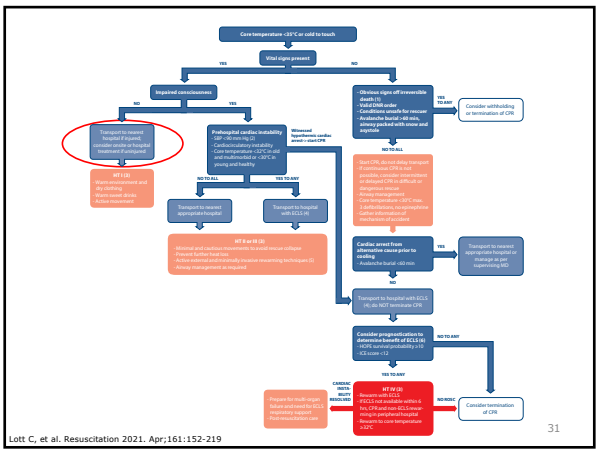

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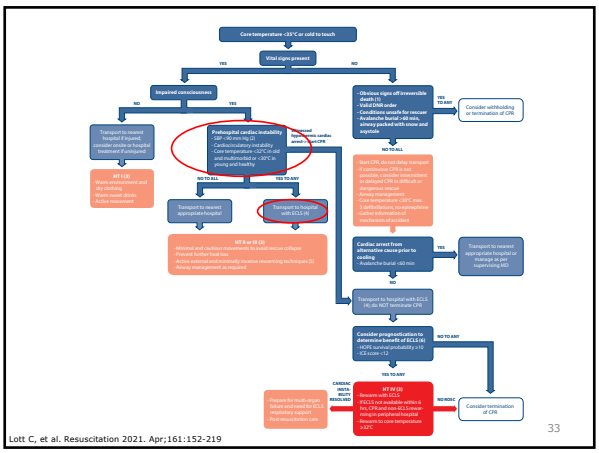

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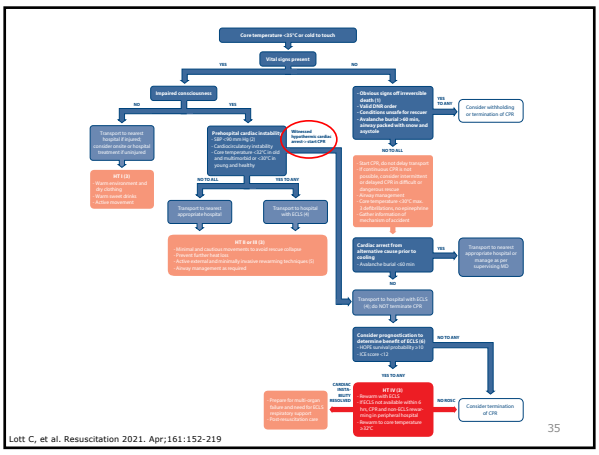

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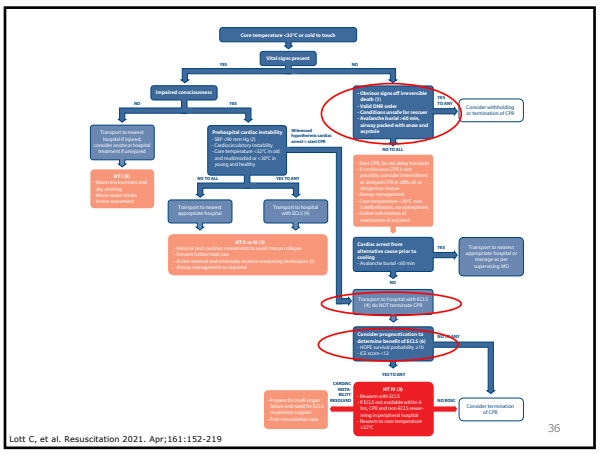

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How to perform CPR?

1. Higher chest compression: ventilation ratio (>30:2)
2. Slower chest compression frequency (min^{-1})
3. Slower ventilation rate
4. This doesn't convince me at all, I stick to the normothermic CPR rules

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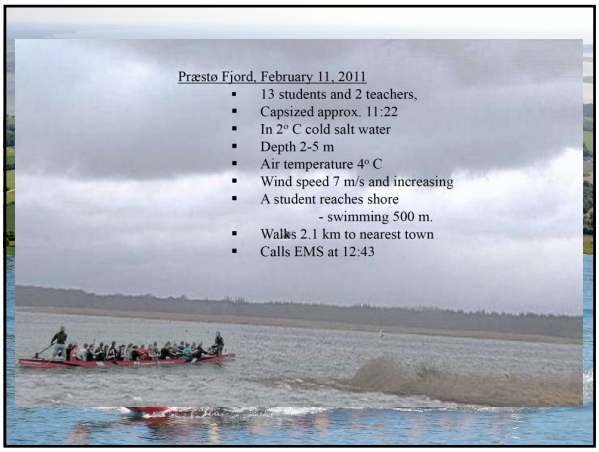

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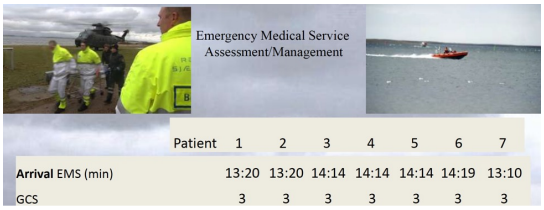

Patient	1	2	3	4	5	6	7
Arrival EMS (min)	13:20	13:20	14:14	14:14	14:14	14:19	13:10
GCS	3	3	3	3	3	3	3

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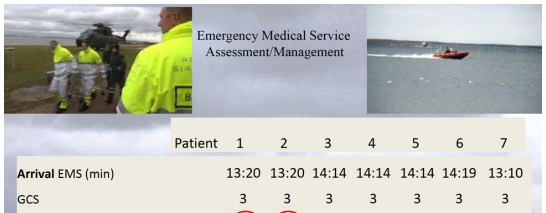

Patient	1	2	3	4	5	6	7
Arrival EMS (min)	13:20	13:20	14:14	14:14	14:14	14:19	13:10
GCS	3	3	3	3	3	3	3
Intubation/ventilation (y/n)	n	n	y	y	y	y	y
CPR (y/n)	y	y	y	y	y	y	y
Helicopter	y	y	y	y			
Rescue boat and Helicopter					y	y	
Rescue boat and ambulance							y

Wanscher M, et al. Resuscitation. 2012 Sep;83(9):1078-84.

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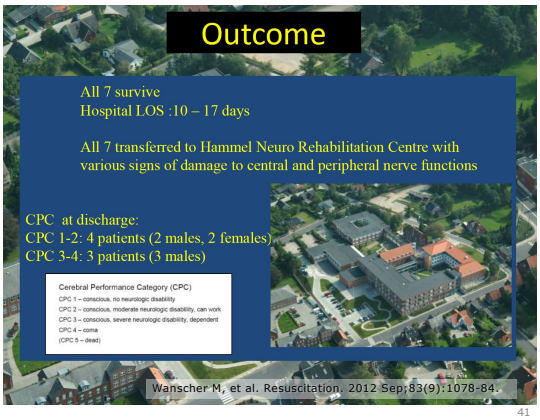

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Quality of manual CPR?

1. 5-20% of normal blood flow?
2. 30-40%
3. 50-70%
4. We have strong team: 80-100%

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CPR

Mechanical

Dembeck A et al. Notfall und Rettungsmed 2011

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CPR

57-yr old woman, 16.9° C,
HR 6min-1. Rescue collapse.
Extrication from above 2000m,
Down over a rock face

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To resuscitate or not resuscitate?

1. Everything comes to an end, the sooner the better
2. We start as soon as we can perform continuous CPR
3. Do CPR whenever you can

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CPR

Intermittent manual CPR
VA ECMO
Good neurologic recovery

Boue Y, et al. Crit Care Med 2014 Feb;42(2):e167-70.

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Resuscitation 90 (2015) 46–49

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

EUROPEAN RESUSCITATION COUNCIL

Commentary and concepts

Delayed and intermittent CPR for severe accidental hypothermia☆

Les Gordon[a,b], Peter Paal[c,d,*], John A. Ellerton[e,d], Hermann Brugger[f,g,d], Giles J. Peek[h,i,j], Ken Zafren[g,l,d]

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[b] Langdale Ambleside Mountain Rescue Team, United Kingdom
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[d] International Commission for Mountain Emergency Medicine (ICAR MEDCOM), Austria
[e] Birbeck Medical Group, Penrith, Cumbria, United Kingdom
[f] Institute of Mountain Emergency Medicine, EURAC Research, Bolzano, Italy
[g] Medical University Innsbruck, Austria
[h] East Midlands Congenital Heart Centre, United Kingdom
[i] Glenfield Hospital, Leicester LE3 9QP, United Kingdom
[j] EuroELSO Steering Committee, United Kingdom
[k] Division of Emergency Medicine, Department of Surgery, Stanford University School of Medicine, Stanford, CA, USA
[l] Medical Director, Alaska Mountain Rescue Group, USA

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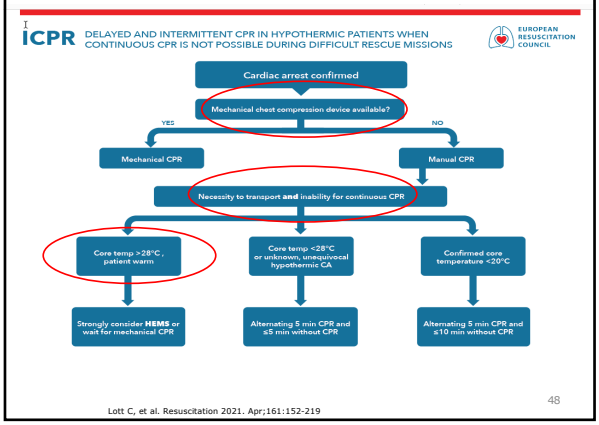

Lott C, et al. Resuscitation 2021. Apr;161:152-219

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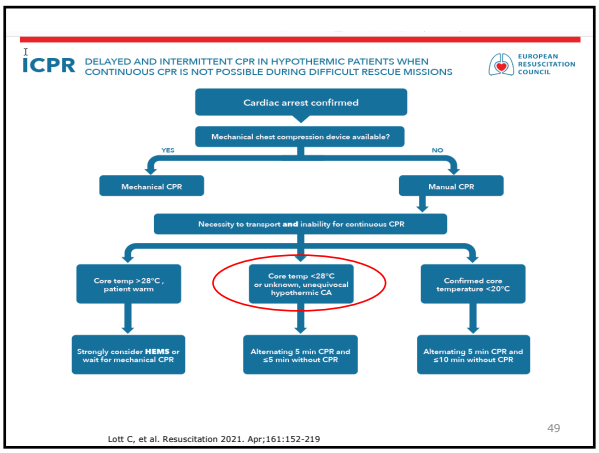

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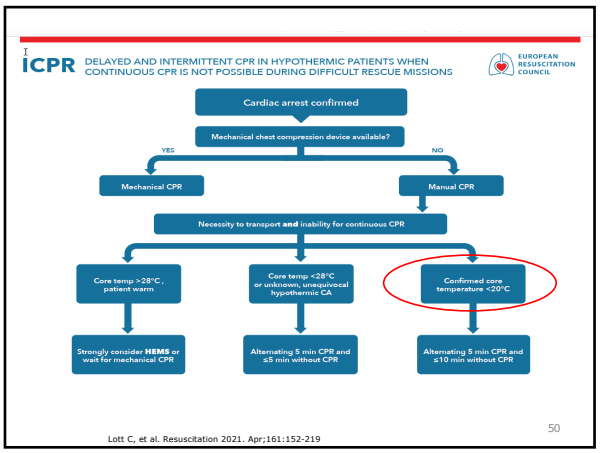

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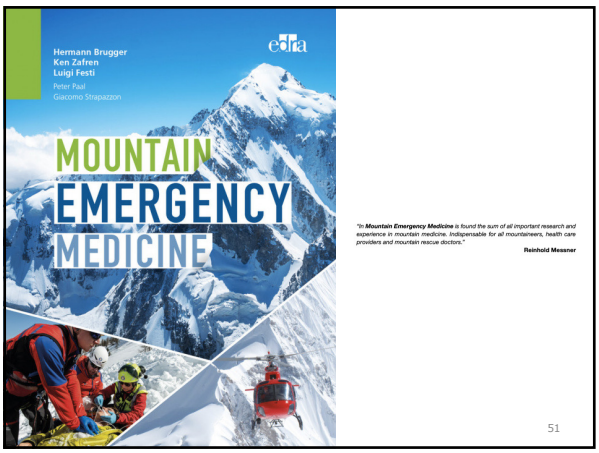

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Hypothermic CA patients

- Hypothermic CA before hypoxia

- Good chances of survival with unwitnessed asystolic CA

- Standard high quality CPR
- Consider delayed or intermittent CPR
- No epinephrine <30° C,
  6-10min intervals ≥30° C

- ECMO/CPB centre

- Prognostication with HOPE

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