Aksidentell hypotermi
Venn og fiende

Torkjel Tvelta
Torvind Næsheim

Hypothermia

- Core temperatur under 35 °C
Hypothermia is not the same as Frostbite.

Patogenesis

Heat production

Heat loss

Regulating

CNS

Hypothalamus

Behavior

Autonomic Nervous system

Somatic Nervous system

Sweat glands

Blod vessels

Brown fat

Skeletal muscle

Evaporative Heat loss

Heat transportation core & skin

Heat production (infants)

Heat production (shivering)

↑ Heat loss

↑ Heat production

+80%

+500%
Cellular mechanisms

Hypothermia

- Enzyme efficiency
- Cellular function
- Metabolism
- Oxygen consumption

Stress reaction

32°C

Ischemia??

Reperfusion damage

Resuscitation

O2-delivery

Organ function

- Perfusion

5-7°C

Cellular injury

Oxygen supply is not a limiting factor during hypothermia

- Spontaneously circulated rats, 15 °C for 2 hours (group 2) and 5 (group 3) hours

Cerebral protection

Therapeutic hypothermia
Therapeutic hypothermic circulatory arrest in aortic arch surgery

<table>
<thead>
<tr>
<th>Extent of Replacement</th>
<th>No. of Patients</th>
<th>No. of Deaths</th>
<th>30-Day Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arch and proximal DTA</td>
<td>25</td>
<td>0</td>
<td>0/10.4</td>
</tr>
<tr>
<td>Arch and entire DTA</td>
<td>34</td>
<td>0</td>
<td>0/17.9</td>
</tr>
<tr>
<td>Most or all of TAA</td>
<td>26</td>
<td>2</td>
<td>7.7/16.2</td>
</tr>
<tr>
<td>Thoracoabdominal aorta</td>
<td>24</td>
<td>1</td>
<td>16.1/26.7</td>
</tr>
<tr>
<td>Crawshay type I</td>
<td>37</td>
<td>6</td>
<td>16.2/25</td>
</tr>
<tr>
<td>Crawshay type III</td>
<td>25</td>
<td>1</td>
<td>4/15</td>
</tr>
<tr>
<td>Total</td>
<td>181</td>
<td>19</td>
<td>6.2/13</td>
</tr>
</tbody>
</table>

Terapeutic hypothermia after cardiac arrest

- Bernard et al., NEJM 2002;346(8):549-56
- Bernard et al., NEJM 2002;346(8):557-63
**Classification**

- Mild hypotermia
- Moderate hypotermia
- Severe hypotermia
- Extreme deep hypothermia

**Organ function**

**Heart, circulation**

- Important not to provoke arrhythmias

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Malte T, Q J Med 2002; 95:775–785


Patton, Journal of Applied Physiology vol 33, no. 6, December 1972

Cardial dysfunction

Pattison. Journal of Applied Physiology vol 33, no. 6, December 1972

Respiratory system

RR, TV, MV
Vasc.perm.
Lung oedema

35 °C
32 °C
28 °C
20 °C
Central nervous system

35 °C
32 °C
28 °C
20 °C

Consciousness
EEG
Pupils

Neuromuscular system

35 °C
32 °C
28 °C
20 °C

Shivering
Reflexes
Neural conduction
Rigidity
Kidneys

- 35 °C
- 32 °C
- 28 °C
- 20 °C

Diuresis

- Perfusion
- pH, electrolytes

Soagulation, platelet function

- 35 °C
- 32 °C
- 28 °C
- 20 °C
Coagulation and temperature

![Graph showing the effect of temperature on coagulation factors activity.](image)

Johnston et al. Journal of Trauma 1994 37(3) 413-417

Platelet aggregation

![Platelet aggregation images at different temperatures.](image)


Trombin activated platelets in vitro
Indication for treatment of accidental hypothermic cardiac arrest?

• "Nobody should be declared dead before warm and dead."

Giesbrecht, Emergency Medicine (2001); 13, 5-14

Akuttbehandling

• Vurdere bevissthet
• Skaffe fri luftvei

BL

• Evnt. assistert ventilasjon
• 100% O2

Å

• Forebygge arrytmî
• Infusjon av varme væsker

S

• Evnt. HLR
• Gir adekvat CO!
• Langvarig
Mechanical chest compression devices

- Superior hemodynamics compared with manual CPR in animal and clinical studies.
- Does not substantially delay starting CPR
- Presents few significant known disadvantages (except cost over standard CPR)
- Decreases interruptions in chest compression during transport
- Creates uniform compression depth across a broader area of the thorax
- Does not interfere with defibrillation efforts.

Advanced life support

- **Defibrillation seldom successful below 28-30 °C.**
  - 3 shock initially.
  - If unsuccessful, wait until core temperature > 30 °C

- **Cardioactive drugs relatively contraindicated**
  - Reduced efficiency
  - Accumulation
  - Adrenergics may be inefficient
  - Vasopressin might be more efficient
  - No medication < 30 °C, double dosage interval > 30 °C, normal doses from 35 °C.
Akuttbehandling

- Fjerne vått tøy, tørke forsiktig, ta på tørt tøy (inkl lue!)
- Dekke med plast for å unngå fordampning
- Temperatur for triage!

Prehospital rewarming?

- **Spontaneous circulation**: Careful core warming – protects against arrhythmia
  - Hotpacs
  - I.V fluids
- **Circulatory arrest**: Avoid rewarming until arrival in adequate hospital – conserves protective hypothermia.

Giesbrecht, Emergency Medicine (2001); 13:3-16
**Transport to hospital**

- Often air ambulance
- Hospital with hypothermia expertise, even if longer transport
- ECG, core temperature, ventilation
- Persistent resuscitation

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**Indications for continued therapy in hospital?**

- NB!! Nobody should be declared dead before warm (32 °C) and dead.
- Cold and dead??
  - Irreversible injuries
  - K+ > 12 mmol/l
  - Coagulated blood

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Giesbrecht, Emergency Medicine 2001; 13: 9-16
Schaller et al. JAMA, October 10, 1995
Giesbrecht, Emergency Medicine 2001; 13: 9-16
Potassium and prognosis

- Lausanne university hospital
- All hypothermic patients between 1984 and 1988

Schaller et al, JAMA, October 10, 1990

Treatment

1. Organ damage
2. Hematologic
3. Ischemia??

- Hypothermia
- Cellular function
- Metabolism
- O2-need
- Perfusion
- O2-offer
Rewarming

External warming
- Immersion warming
- Convective air warming
- Extra corporeal circuit
  - CPB
  - CAVR
  - CVVR

Internal warming
- Peritoneal lavage
- Mediastinal lavage
- Ventricular lavage

Aktive eksternal rewarming

Sources:
- Aktive eksternal rewarming 1998; 25:62±68
- Koller, Acta Anaesthesiol Scand 1998; 41:1359±1364
CPB

Afterdrop

A. femoralis

V. femoralis

Heat exchanger

Active rewarming
Rewarming shock

- Pulmonary hypertension
- ↓ inotropia
- Hypovolemia
- Extravasation

CNS disturbance
- Neurohumoral insufficiency
- SIRS
- Electrolyte disturbance
- Acidosis

Fluid balance

- Extravasation during CPB
  - Intravascular albumin- and proteinmass unchanged
  - Can be counteracted by using iso-oncotic prime
  - Hyperosmolar/hyperoncotic solutions might reduce extravasation
  - Low perfusion pressure during CPB dos not reduce extravasation
  - No effect of steroids

- Extravasation during exposure hypothermia
  - Capillary dysfunction, protein leak
  - Centralization of circulation
Fluid balance

Brain oedema

- Ischemic damage?
- Capillary leak?
  - Hypothermia induced
  - CPB-associated
  - Multi organ failure
- Excessive hydration during resuscitation?
  - Fluid balance critical
  - Colloids vs crystalloids
  - CPB critical
Oppskrift på en suksess...

- Ekstremt godt trenet pasient
- Gunstig nedkjølingsmekanisme
- Adekvat basal hjerte-lungeredning
  - Tidlig og adekvat varsling
  - Effektiv transportkjede
  - "Load and go"
- Temperaturkonservering under transport
- Adekvat hjerte-lungeredning under transport
- Effektivt mottak på sykehus
- Tilpasset oppvarmingsmetode
- Kompetent intensivbehandling
  - Motivert pasient
  - Omfattende rehabilitering