Environmental Emergencies – Hypothermia and Heat Stroke: Cases from the Emergency Department
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Mechanisms for heat exchange
- Conduction – water 25x more conductive than air
- Convection – wind chill effect. Normally a 3mm layer of air provides insulation in calm conditions
- Radiation – works both ways, i.e. heat from sun vs. losses to ambient environment
- Evaporation – insensible losses and sweating. Effect depends on temperature and humidity gradient

Risk factors for accidental hypothermia or heat illness:
- Very old or very young
- Medications
- Comorbid illness (e.g. decreased reserves, cardiac output)
- Substance abuse/immobility
- Poor judgement, neurologic or psychiatric illness
- Exercise/workplace environment

Clinical definition of heat stroke:
- Hyperthermia, multi-organ dysfunction, and altered level of consciousness
- A cutoff of 40 degrees is often used to define heat stroke. The number is somewhat arbitrary given that a) most have cooled somewhat prior to receiving care, and b) risk is determined both by the temperature and the length of the exposure

Complications of heat stroke:
Early: encephalopathy, hepatic injury, increased basal metabolic rate
Late: rhabdomyolysis, renal insufficiency, bowel ischemia, DIC, sepsis

Clinical definition of moderate to severe hypothermia:
- Core temperature less than 32C, not shivering, and altered level of consciousness
- There is variability in the exact temperature at which clinical symptoms such as shivering appear or disappear.

Complications of moderate to severe hypothermia:
Early: CNS depression, bradycardia, hypotension, atrial fibrillation/other arrhythmias
Late: pulmonary edema, renal failure, hypoglycemia/hyperkalemia, bleeding diathesis, peripheral cold-induced injury
<table>
<thead>
<tr>
<th>Condition</th>
<th>Intervention</th>
<th>Goal</th>
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<tbody>
<tr>
<td>Out of hospital</td>
<td>Measure the patient’s core temperature (with a rectal probe) if the core temperature is &gt;40°C,</td>
<td>Diagnose heat stroke†&lt;br&gt;Lower the core temperature to &lt;30.4°C, promote cooling by conduction, and promote cooling by evaporation</td>
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<td>Heat stroke (due to heat wave, summer heat, or possible internal cooling; cold packs on the neck, axilla, and groin; continuous fanning (or opening of the ambulance windows); and spraying of the skin with water at 25°C to 30°C. Position an unconscious patient on his or her side and clear the airway. Administer oxygen at 4 liters/ min. Give isotonic crystalloid (normal saline). Rapidly transfer the patient to an emergency department.</td>
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<td>Heat stroke (due to heat wave, summer heat, or</td>
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<td>Minimize the risk of aspiration. Increase arterial oxygen saturation to &gt;90%. Provide volume expansion.</td>
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<td>changes in mental status (anxiety, delirium, seizures, or coma)</td>
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<td>In hospital</td>
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<td>Cooling period</td>
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<td>Hyperthermia</td>
<td>Monitor the rectal and skin temperatures; continue cooling.</td>
<td>Keep rectal temperature &lt;30.4°C§ and skin temperature 30°C–33°C. Control seizures. Protect airway and augment oxygenation (arterial oxygen saturation &gt;90%). Increase mean arterial pressure to &gt;60 mm Hg and restore organ perfusion and tissue oxygenation. Prevent myoglobin-induced renal injury: promote renal blood flow, diuresis, and alkalization of urine. Prevent life-threatening cardiac arrhythmia.</td>
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<td>Seizures</td>
<td>Give benzodiazepines.</td>
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<td>Respiratory failure</td>
<td>Consider elective intubation (for impaired gag and cough reflexes or deterioration of respiratory function)</td>
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<td>Hypotension†</td>
<td>Administer fluids for volume expansion, consider vasopressors, and consider monitoring central venous pressure.</td>
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<td>After cooling Multiorgan dysfunction</td>
<td>Monitor serum potassium and calcium levels and treat hyperkalemia.</td>
<td>Recovery of organ function</td>
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<td>Supportive therapy</td>
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</table>

*Data are from Knochel and Reed; Graham et al; Wyndham et al; Weiner and Khogali; Al-Aska et al; White et al; Bouchama et al.†Heat stroke should be suspected in any patient with changes in mental status during heat stress, even if his or her core temperature is <40°C.‡There is no evidence that one cooling technique is superior to another. Noninvasive techniques that are easy to apply, well tolerated, and not likely to cause cutaneous vasoconstriction are preferred.§There is no evidence to support a specific temperature end point at which cooling should be halted. However, a rectal temperature of 39.4°C has been used in large series and has proved to be safe.¶Hypotension usually responds to volume expansion and cooling. Vasodilatory shock and primary myocardial dysfunction may underlie sustained hypotension that is refractory to volume expansion. Therapy should be individualized and guided by the patient's clinical response.
Management of moderate to severe accidental hypothermia

Patient's trunk feels cold on examination or core temperature is <35°C

Vital signs present

Yes

Impaired consciousness

No

Ventricular arrhythmias
Core temperature <28°C

Prehospital cardiac instability
Systolic blood pressure <90 mm Hg

Transport to nearest hospital if injured; consider onsite or hospital treatment if uninjured

HT I
Provide warm environment and clothing
Provide warm sweet drinks
Encourage active movement

Transport to nearest appropriate hospital

HT II or III
Minimize movements to prevent arrhythmias
Prevent further heat loss
Use active external and minimally invasive rewarming techniques
Provide airway management as required

Cardiac arrest before cooling
Major trauma
Witnessed normothermic arrest
Avalanche burial <35 min

Consider tests to confirm need for ECMO or CPB
Core temperature <32°C
Serum potassium <12 mmol/liter

Transport to hospital with ECMO or CPB; do not terminate CPR

Prepare for multiorgan failure and need for ECMO respiratory support
Provide post-arrest management
Consider therapeutic hypothermia
32–34°C for 24 hr

Cardiac instability resolved

HT IV
Rewarm with ECMO or CPB
If ECMO or CPB not available, provide CPR with active external and alternative internal rewarming
Rewarm to 32°C core temperature

No ROSC

Consider termination of CPR

Start CPR, do not delay transport
Prevent further heat loss
Provide airway management and up to 3 doses of epinephrine (at an IV or IO dose of 1 mg) and defibrillation

Consider termination of CPR

No to all

Yes to any

Obvious signs of irreversible death
Valid DNR order
Conditions unsafe for rescuer
Avalanche burial ≥35 min, airway packed with snow, and asystole

No to all

Yes to any

Management and Transport in Accidental Hypothermia.

HT I, HT II, HT III, and HT IV refer to four stages of hypothermia as defined by the Swiss staging system. HT II and higher will progressively altered mental status and no shivering.

Obvious signs of irreversible death include decapitation, truncal transection, decomposition of the whole body, and a chest wall that is not compressible (i.e., the whole body is frozen solid).

Rigor mortis as well as fixed and dilated pupils may be present in patients with reversible hypothermia. Active external and minimally invasive rewarming techniques include placement of the patient in a warm environment; use of chemical, electrical, or forced-air heating packs or blankets; and parenteral administration of warm fluids (38 to 42°C).

A systolic blood pressure of less than 90 mm Hg is a reasonable prehospital estimate of cardiac instability, but for in hospital decisions, the minimum sufficient circulation for a patient with a core temperature of less than 28°C has not been defined. Therefore, it is not known at what point a patient with refractory cardiac instability should be transitioned to extracorporeal membrane oxygenation (ECMO) or cardiopulmonary bypass (CPB).

In remote areas, the transport adviser must balance the risk of increased transport time with the potential benefit of treatment in a center that can provide ECMO or CPB. For a patient with cardiac arrest in a remote area, the need for ECMO or CPB can be confirmed by measuring the serum potassium level at an intermediate hospital, ideally en route toward a center that can provide ECMO or CPB. When transfer to such a center is not feasible, active external and alternative internal rewarming techniques should be used. DNR denotes do not resuscitate, IO intraosseous, IV intravenous, and ROSC return of spontaneous circulation.

Selected References:

Atha, W  Heat-related Illness Emerg Med Clin NAm 2013;31:1097-1108

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