Hypothermia

February 10, 2017 by Josh Farkas

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staging

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growing started

- Definitions
- Hypothermia is defined as <35°C (95°F).
- Temperatures <36 (96.8) raise concern for sepsis.
- Hypothermia should be treated with respect (it’s generally more ominous than fever).

### clinical consequences of hypothermia

<table>
<thead>
<tr>
<th>Severity</th>
<th>Neurologic</th>
<th>Cardiac</th>
<th>Pulmonary</th>
<th>Renal</th>
<th>Typical therapy*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild (HT1)*</td>
<td>Alert, shivering*</td>
<td>Tachycardia</td>
<td>Tachypnea</td>
<td>Cold diuresis</td>
<td>- Exposure-related. Passive external rewarming (e.g. blanket)</td>
</tr>
<tr>
<td>32-35C</td>
<td>Ataxia</td>
<td>Hypertension</td>
<td>Bronchitis</td>
<td>- Spontaneous. Warming blanket</td>
<td></td>
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<tr>
<td>90-95F</td>
<td>Impaired judgement</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Moderate (HT2)*</td>
<td>Drowsy, non-shivering*</td>
<td>Bradycardia</td>
<td>Hypoventilation</td>
<td>Cold diuresis</td>
<td>Active external rewarming</td>
</tr>
<tr>
<td>28-32C</td>
<td>Delirium</td>
<td>Hypotension</td>
<td></td>
<td></td>
<td>- Warming blanket</td>
</tr>
<tr>
<td>82-90F</td>
<td>Paradoxical undressing</td>
<td>Atrial fibrillation</td>
<td></td>
<td></td>
<td>- Warmed/humidified air</td>
</tr>
<tr>
<td>Severe (HT3)*</td>
<td>Unconscious with pulse*</td>
<td>Heart block</td>
<td>Pulmonary edema</td>
<td>Oliguria</td>
<td>- Active external rewarming (see above).</td>
</tr>
<tr>
<td>24-28C</td>
<td>Coma</td>
<td>Cardiogenic shock</td>
<td>Agonal respirations</td>
<td></td>
<td>- If refractory shock or hypothermia, also consider active internal warming (e.g. thoracic/bloodlet lavage).</td>
</tr>
<tr>
<td>75-82F</td>
<td>Fixed dilated pupils</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulseless (HT4)*</td>
<td>Apneic</td>
<td>Pulsatile*</td>
<td>Apnoea</td>
<td>Active external rewarming plus</td>
<td></td>
</tr>
<tr>
<td>&lt;24C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Active internal rewarming</td>
</tr>
<tr>
<td>&lt;75F</td>
<td></td>
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<td></td>
<td>- Ideally: ECMO or cardiopulmonary bypass</td>
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<td></td>
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<td></td>
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<td>- Alternative: thoracic lavage</td>
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</table>

Staging and treatment of hypothermia. The provided temperature ranges generally correlate with clinical findings, but this correlation isn’t perfect. When classifying the severity of hypothermia, both the temperature and clinical manifestations should be considered.

* Say clinical features which may be used to stage patients in the field (if immediate temperature measurement isn’t available).
* Swiss Staging system for hypothermia.
* Therapy depends on clinical details, response to prior treatments, available resources, and risk/benefit calculus for each intervention. Listed treatments in this column are merely provided to give a general concept of how these patients might often be managed.

The table above summarizes the clinical effects of different levels of hypothermia. This isn’t 100% accurate, but may provide a general idea of whether the patient’s condition can be explained by the degree of hypothermia, or whether something else is going on. For example, mild hypothermia cannot explain a coma.

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**Sam Ghali, M.D.**
@EM_RESUS

**#ECG** of a hypothermic patient with core body temp of ~84°F

1. Classic Osborn waves (J waves)
2. Prolonged QTc
3. Shivering artifact most prominent in the limb leads! **#FOAMed**

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### causes of hypothermia

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**obvious trigger**

- Cold exposure
- Massive transfusion
- Dialysis
- Surgery

**distributive shock**

https://emcrit.org/ibcc/hypothermia/
- Sepsis
- Pancreatitis (can get confusing: hypothermia may cause mild pancreatitis)

**metabolic**
- Hypoglycemia
- Diabetic ketoacidosis
- Hypothyroidism
- Adrenal insufficiency
- Thiamine deficiency
- Malnutrition, anorexia nervosa

**toxicologic**
- Ethanol, sedatives, opioids
- Phenothiazines, cyclic antidepressants
- Sympatholytics (beta-blockers, alpha-blockers)
- Central alpha-agonists (e.g. clonidine)
- Carbon monoxide poisoning
- Lithium toxicity

**neurologic**
- Spinal cord injury
- Multiple sclerosis, Parkinson's disease
- Thalamic injury (e.g. stroke)

**initial investigation**

**core temperature measurement**
- Esophageal probe might be ideal for intubated patients (may track most closely with real-time core temperature).
- Bladder probe may be used for any patient.
- Rectal probe if neither of the above is available.

**hypothermia lab panel**
- Check a fingerstick glucose immediately.
- Basic labs (CBC, electrolytes).
- Coags & fibrinogen.
- Lactate.
- Cortisol.
- TSH and free T4.
- Creatinine kinase.
- Blood cultures if infection is possible.
- Additional toxicology workup as is appropriate.

**resuscitating the hypothermic pulseless patient**

*Pulseless, hypothermic patients create a very challenging situation. To be considered dead, the patient's core temperature must be at least ~32 C (“warm and dead”).*

**a brief word on pre-hospital management**
Rewarming should start pre-hospital, to the extent that this is possible.

Extended CPR should be performed (hypothermic patients can have excellent outcomes despite hours of CPR). Patients can even do OK despite brief pauses in CPR, because hypothermia protects the brain from injury.

Transport to an ECMO center may be beneficial, even if it’s not the closest hospital. Ideally, pre-hospital systems should have protocols in place to identify ECMO candidates and triage them appropriately (including communication with the receiving hospital, which can then prepare to receive the patient).

**modifications to standard ACLS algorithms in hypothermia**

- Medications may fail to be metabolized and accumulate. Therefore, avoid repeated doses of medications.
- Defibrillation may be unsuccessful until the patient is rewarmed. Thus, serial shocks for VT/VF arrest are unlikely to add benefit. As the patient rewarms, further attempts may be made at defibrillation.

**VA ECMO or cardiopulmonary bypass**

- This is the cadillac of the hypothermic pulseless resuscitation, if available.
- Benefits are numerous:
  - (a) It supports organ perfusion.
  - (b) ECMO circuit can be used to warm the patient (via in-line warmer) at 7-10°C per hour.
  - (c) It allows you to stop compressions.
- Case reports describe excellent outcomes for patients with accidental hypothermia.
- If ECMO or cardiopulmonary bypass are not available, other options may include any extracorporeal blood circuit that involves an in-line fluid warmer (e.g. hemodialysis).

**thoracic lavage**

- This can achieve 3-6°C warming per hour.

**Traditional strategy involves two chest tubes.**

- You may place one anterior chest tube and one lateral chest tube, if you’re comfortable with anterior chest tubes (making sure to avoid vascular structures, e.g. the internal mammary artery). Alternatively, two chest tubes may be placed in the lateral chest, with one directed more anteriorly and one directed more posteriorly.
- Using the left pleura may be superior for directly warming the myocardium. If possible, it may be most effective to perform this simultaneously on both sides of the chest (with a total of four chest tubes).
- Infuse warmed crystalloid (temperature of 42°C or 107°F) into the more anterior chest tube. The ideal approach is to attach the chest tube to a Level-I or Belmont fluid warmer/infuser. If this isn't available, there are reports of using warm tap water (26655247).
- Drain fluid from the chest by attaching the posterior chest tube to a drainage system. The volume of fluid administered may rapidly fill a standard chest tube drainage system (Pleurovac). For intubated patients, the chest tube may be attached to any sterile receptacle (positive intrathoracic pressure should promote fluid drainage out of the chest, without the need for external suction).
- Carefully monitor fluid drainage (if the lower chest tube kinks or becomes dysfunctional, ongoing instillation of warmed fluid may generate a tension hydrothorax).

**Alternative strategy involves placement of only one chest tube.**

- Place one large-bore chest tube in the lateral chest, directed posteriorly.
- Instill 300-500 ml of warmed fluid, clamp the chest tube for 15 minutes, then drain fluid and repeat.
- Carefully monitor for pneumothorax. If there is laceration of the lung (e.g. due to CPR or chest tube insertion), a tension pneumothorax could develop while the chest tube is clamped. Thus, this strategy is only viable in the absence of lung laceration (in the presence of a pre-existing pneumothorax or lung laceration, a two-tube strategy described above must be used).

**bladder lavage**

- Less effective than thoracic lavage, but it may be considered if it won’t detract from other therapies.
- Two ways to achieve this:
  - i) Use a dedicated 3-way Foley catheter with continuous irrigation of warmed fluid (~42°C).
  - ii) Instill 300 ml of warmed fluid, clamp the Foley for 15 minutes, then drain the bladder and repeat.

rewarming a patient with pulses
The following measures may be considered for patients with moderate or severe hypothermia (or mild hypothermia with failure to rewarm with less aggressive measures).

(1) external warming

- Two general options exist, depending on available resources and the patient’s level of acuity:
  - (i) Warming blankets (e.g. heated-air systems such as the “Bair Hugger”).
  - (ii) External adaptive temperature control device using a circulating water bath (e.g. Arctic Sun).
    - Direct contact with the skin may increase thermal conductivity between the device and the patient, thereby accelerating effective warming.
    - This is expensive (a set of pads may cost >$1,000).
    - May be used for patients not responding to warming blankets.
    - Should be used for patients with cardiac arrest or severe neurologic injury, because this device will prevent over-shoot hyperthermia. Once these patients are successfully resuscitated, they may be maintained at 36C using a targeted temperature management approach.

(2) warming via the lungs

- The alveoli have the combined surface area of a tennis court. They are usually a source of heat loss from the body.
- Providing heated, humidified gas reverses this: instead of losing heat from the lungs, patients gain heat.
- For non-intubated patients, this may be accomplished as follows:
  - i) High-flow nasal cannula (at maximal temperature setting). This may be preferred for patients with altered mental status and risk of emesis.
  - ii) CPAP or BiPAP using in-line heated humidification. This may be done using either a BIPAP device or a formal mechanical ventilator (if the usual BiPAP device lacks the ability to heat and humidify gas).
- For intubated patients, this may be performed by heating and humidifying the ventilator circuit (work with the respiratory therapist to make sure this is adjusted to the warmest setting possible).

(3) more invasive measures (thoracic and/or bladder lavage)?

- There isn’t any high-quality evidence on this, so it’s a clinical decision based on the individual patient.
- Most patients with a pulse will respond to the above measures (#1-2).
- Arguments favoring more invasive treatment might include the following:
  - (i) Failure of less invasive measures to successfully warm the patient
  - (ii) Profound shock
  - (iii) Lower core temperature (e.g. <28C)
- If thoracic lavage is pursued, right-sided lavage might be superior (to avoid stimulating the heart and thereby inducing an arrhythmia).

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**general resuscitative measures**

airway

- Intubate if necessary. However, if possible, it’s preferable to avoid or delay intubation (to allow for stabilization and warming prior to the hemodynamic stress of intubation).

access

- If central access is needed, make sure not to stimulate the ventricle with the guidewire (cold hearts are very susceptible to VT/VF).
- A femoral line might be the preferred site. The alternative is placing an upper extremity line, with careful attention to keep the guidewire relatively shallow.

cardiovascular

- Bradycardia
Hypothermia itself causes bradycardia. Trying to speed up the heart with medications or pacing is generally a mistake, as this may precipitate ventricular tachycardia.

- The key therapy for bradycardia is re-warming.

**Hypotension**
- Mild/moderate hypotension is common and should resolve with rewarming.
- Be cautious with vasopressors, given the risk of inducing arrhythmias.
- Vasodilation can occur with rewarming, so if blood pressures fall with rewarming this could be a better indication for vasopressors.

### fluid & electrolytes

**Volume management**
- Crystalloid should be administered only if the patient is felt to be clinically hypovolemic.
  - Hypothermia often stimulates diuresis (“cold diuresis”), so patients are often volume depleted.
  - Additional factors (clinical history, echocardiography) may help determine whether crystalloid is needed.
- If crystalloid is given, it should ideally be warmed. Warming the fluid prevents dropping the patient’s temperature further. However, giving warmed fluid is not an effective strategy for increasing the patient’s temperature (figure below).
- Method of rewarming:
  - This is ideally done using an in-line warming device (e.g. Level-I infuser, Belmont).
  - If no rewarmer is available, fluids can be warmed by placing each liter in a microwave oven on high for ~2 minutes. Shake before administration to equilibrate the temperature. Fluid bags should feel comfortably, mildly warm (26655247, 10671843).

![Using chilled fluid in a hyperthermic patient](image1)

**Rebound hyperkalemia**
- Hypothermia tends to cause hypokalemia. With re-warming, the potassium will tend to rise.
- Be conservative in the administration of potassium while the patient is still hypothermic (this may promote rebound hyperkalemia).
- Patients with prolonged cardiac arrest may eventually develop hyperkalemia. Thus, an admission potassium above >12 mM is an extremely poor prognostic sign (in a pulseless patient this may indicate futility of further resuscitation).

**Rebound hypoglycemia**
- Glucose may initially be elevated, due to catecholamine release and insulin resistance (both resulting from hypothermia).
- Avoid giving lots of insulin while the patient is still hypothermic (insulin may accumulate and cause rebound hypoglycemia once the temperature improves).

### Rhabdomyolysis & DIC

**Rhabdomyolysis**

https://emcrit.org/ibcc/hypothermia/
This may be caused by hypothermia.
If present, consider a somewhat more generous fluid resuscitation (more on rhabdomyolysis [here](https://emcrit.org/ibcc/rhabdo/)).

### hematologic

Hypothermia causes a clinical tendency to bleed despite normal levels of clotting factors.
- Usually, the measured levels of clotting factors will be normal (the lab measures these after warming blood to 37°C).
- The only way to reverse this coagulopathy is re-warming. For active hemorrhage in the hypothermic patient, desmopressin might improve platelet function ([Hanke 2010](https://emcrit.org/wp-content/hypoarts/effects%20of%20hypothermia%20on%20pts%20with%20ddavp.pdf)).
- Less commonly, hypothermia may also cause disseminated intravascular coagulation (DIC). In this case, measured levels of coagulation labs will be low.
- Subcutaneous heparin for DVT prophylaxis is contraindicated in severe hypothermia, due to poor skin absorption.

Subcutaneous heparin for DVT prophylaxis is contraindicated in severe hypothermia, due to poor skin absorption.

### treating underlying issues: sepsis, adrenal insufficiency, myxedema

For patients without an obvious cause of hypothermia, consideration should be given to all possible causes. Many of these are listed above, but three are most important regarding immediate management.

### sepsis

Hypothermia commonly occurs due to sepsis (particularly if no other cause is evident).
- If infection is suspected, consider starting empiric antibiotics. A reasonable approach is often to start a single broad-spectrum agent (e.g. piperacillin-tazobactam). This should be stopped within 48 hours unless there is further evidence to support infection (e.g. positive procalcitonin or positive blood culture results).

### consider empiric therapy for myxedema coma or adrenal insufficiency

Hypothyroidism and adrenal insufficiency can both cause hypothermia and must always be considered.
- In very ill patients, it may be appropriate to start therapy immediately (even before confirming the diagnosis).
- Myxedema coma:
  - Empirc therapy may be considered (depending on the index of suspicion and the turn-around time for thyroid function labs). This may consist of a single dose of 250 mcg IV levothyroxine. Make sure a full thyroid panel of labs is drawn before this is administered.
  - Stress-dose steroid is generally administered simultaneously with thyroid replacement (to prevent precipitation of adrenal crisis, in case there is dysfunction of both glands).
- Adrenal insufficiency:
  - Treating this empirically is extremely reasonable for hypothermic, shocky patients.
  - Start dexamethasone (4-6 mg of IV) while awaiting the serum cortisol level. Dexamethasone is used because it doesn't interfere with the cortisol test.
  - Further management depends on the cortisol level:
    - If cortisol levels are low (<20 ug/dL), then an ACTH stimulation test should be performed immediately to clarify whether the patient truly has adrenal insufficiency.
    - If cortisol levels are adequate (>20 ug/dL), then adrenal insufficiency is excluded.

### checklist

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Approach to hypothermia

Lab panel
- Fingerstick glucose (STAT)
- Basic labs (CBC, electrolytes, INR/PTT, fibrinogen)
- Lactate, creatinine kinase (beta-hydroxybutyrate if diabetic)
- If cause of hypothermia not obvious: Cortisol, TSH, free T4, blood cultures, additional toxicology workup as indicated (e.g. carboxyhemoglobin level)

Rewarming modalities
- External warming (warming blankets vs. circulated-water temperature management system)
- Respiratory warming (HFNC if not intubated, or heated humidification via ventilator)
- Warm any fluids administered (but give fluid only if indicated, based on volume status)
- Pulseless or refractory to above measures: Consider ECMO, cardiopulmonary bypass, or thoracic lavage

Medical therapies which may be considered
- These are useful mostly for either hypothermia of unknown etiology and/or refractory hypothermia.
- Adrenal crisis suspected: Dexamethasone 4-6 mg IV once.
- Myxedema coma suspected: 250 mcg IV levothyroxine plus dexamethasone 4-6 mg IV.
- Sepsis suspected: Empiric antibiotics
- Thiamine deficiency possible: Empiric IV thiamine

Complications to lookout for
- Rhabdomyolysis
- Electrolyte & glucose shifts
- Pulmonary edema
- Disseminated intravascular coagulation (DIC)

-The Internet Book of Critical Care, by @Pulmcrit

podcast

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questions & discussion

To keep this page small and fast, questions & discussion about this post can be found on another page here.
Hypothermia may induce diuresis ("cold diuresis"). Thus, adequate urine output doesn't necessarily indicate adequate renal perfusion.

Unexplained hypothermia often signals severe illness: this should be a trigger to provide aggressive and thoughtful resuscitation.

Most standard thermometers don't read below 34C, so these may fail to detect severe hypothermia. If the patient feels cold but the thermometer isn't reading low, obtain a core temperature as described above.

Hypothermia may mask EKG changes due to hyperkalemia. When in doubt about whether a potassium level is real, repeat it immediately (e.g. using a point-of-care monitor at the bedside) and treat accordingly.

Going further:

- Severe accidental hypothermia (https://emcrit.org/emcrit/severe-accidental-hypothermia/) (Scott Weingart, EMCrit RACC podcast #66)
- Hypothermia (https://littl.com/hypothermia/) (Chris Nickson, LITFL)
- Hypothermia (https://wikem.org/wiki/Hypothermia) (WikEM)