Accidental Hypothermia: An Evidence-Based Approach

Three physicians, 3 cities, 3 patients, 1 theme — and many questions:

Oakland, California: Change of shift on a busy, rainy Friday in January. A John Doe appearing to be in his 50’s is brought in by EMS after being “found down” with obvious ethanol alcohol (ETOH) on board. He is intubated, pulseless, cold to touch, and CPR is in progress. While the ET tube placement is confirmed, the nurse places a Foley catheter and reports that his temperature is 25°C (77°F). When CPR is paused, the monitor shows ventricular fibrillation. A forced air warming device is requested STAT while the physician begins to think about the next steps. The hospital does not have cardipulmonary bypass and the physician wonders, “Should ACLS guidelines be followed? Should the patient be transferred to a higher level facility? Is there a role for hemodialysis? Does this patient even have a chance of surviving?”

Jackson Hole, Wyoming: EMS calls in that they have a hypothermic, 30-year-old female who had probably gotten lost while backcountry skiing, though fortunately made it to a roadside before collapsing. It was unclear how long she had been down before she was found by a passing motorist. The medics report she is breathing and has a pulse but is unconscious; they have an estimated time of arrival (ETA) of 15 minutes. The paramedics request permission to intubate the patient. As the physician considers the situation and the medical code initial presentation, with special regard to the medical code situation.

Jacksonville, Florida: An 80-year-old man is brought in from a skilled nursing facility with altered mental status. The core temperature measured via the Foley catheter is 32°C (89.6°F). Unsure of the patient’s baseline or physical abnormalities.

Jacksonville is an 80-year-old man who had been down for some time. His core temperature measured via the Foley catheter is 32°C (89.6°F). Unsure of the patient’s baseline or physical abnormalities.

American Academy of Family Physicians (AAFP) through the sponsorship of EB Medicine. EB Medicine is accredited by the ACCME to provide continuing medical education for physicians. Faculty Disclosure: Dr. Mulcahy, Dr. Watts, Dr. Weingart, Dr. Jagoda, and their related parties report no significant financial interest or other relationship with the manufacturer(s) of any commercial product(s) discussed in this educational presentation. Commercial Support: Emergency Medicine Practice does not accept any commercial support.
etiology of the hypothermia, the physician places a forced air rewarming device on the patient, administers warm humidified oxygen, and reflects, “Should I give the patient broad spectrum antibiotics or wait to see if his mental status improves? Should I give him steroids? How aggressively should I warm him?”

From Florida to Alaska, hypothermia is prevalent in every emergency department (ED) regardless of location or time of year. In the United States, there are more than 650 deaths per year from primary hypothermia with 66% of the deaths occurring in men. Beyond that, there are an unknown number of deaths where hypothermia is a secondary or contributing cause.¹

Hypothermia occurs in a wide variety of environmental settings and is complicated by multiple patient co-morbidities. It does not have to be a subzero night in Wyoming to encounter severely hypothermic patients. The homeless, intoxicated patient in Miami is also at risk for accidental hypothermia. The states with the highest hypothermia-related death rates are those with milder climates that experience rapid temperature changes (eg, North Carolina and South Carolina) and western states that have high elevations and considerable changes in nighttime temperatures.²

The best strategy to manage the hypothermic patient must be individually tailored and varies depending on the resources available. However, there are basic principles that apply to all hypothermic patients. Some hypothermic patients can make seemingly miraculous recoveries and must be treated very differently than their normothermic counterparts. The adage that “a person is not dead until he is warm and dead” is corroborated by the fact that the lowest initial temperature recorded in a child who survived from hypothermia was 14.2°C (57.6°F),³ and the lowest recorded temperature in an adult was 13.7°C (56.7°F).⁴

This issue of Emergency Medicine Practice reviews the evidence and current understanding of the pathophysiology, clinical assessment, and treatment options for maximizing outcomes in accidental hypothermia.

**Critical Appraisal Of The Literature**

Accidental hypothermia may be one of the oldest human afflictions; it is tied to the most basic of human needs for warmth and shelter. Medical literature is replete with miraculous survival stories, and there is an abundance of case reports and retrospective reviews of plausible hypothermia treatment and rewarming techniques. Unfortunately, there is a striking absence of large scale prospective or randomized clinical investigations within this body of literature. Even the experts in the field admit that it has not been possible to derive a strong evidence-based practice guideline for the treatment of accidental hypothermia.⁶ Without strong outcomes, research, or evidence to show clear survival benefit, it is not possible to provide a high-level recommendation for the best approach to rewarm the hypothermic patient.

Searches of numerous evidence-based medicine data banks were performed, including the National Guideline Clearinghouse, Cochrane Database of Systematic Reviews, Evidence Based Medicine Reviews: Best Evidence (ACP), Database of Abstracts of Reviews of Effectiveness (DARE), and Evidence Based Medicine Reviews Multifile (EBMZ). Only the National Guideline Clearinghouse provided any results for accidental hypothermia.

There were only 2 published protocols identified for the treatment of hypothermia: The State of Alaska Cold Injuries and Cold Water Near Drowning Guidelines (last revised 1/2005) and the American Heart Association Guidelines from 2005.⁷ ⁸ The AHA also has specific hypothermia guidelines within the larger context of its BLS and ACLS protocols.⁹ A search on guidelines.gov also yielded guidelines on hypothermia treatment in the first aid and advanced life support sections from the 2005 International Consensus Conference on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations and the 2005 European Resuscitation Council’s recommendations on cardiopulmonary arrest in special circumstances.¹⁰ ¹¹ All of these guidelines are derived from a few prospective studies that look at the various warming techniques for treating moderate to severe hypothermia, numerous case series and case reports, and studies on intra-operative hypothermia and experimental hypothermia.¹² ¹⁵

Within the past 10 years, several authors have attempted to develop management recommendations based on a systematic review of the literature; however, the diversity in study and reporting design has undermined their success.¹⁶ ²⁴ ²⁶-²⁸ Although the evidence is weak, the volume of information on this topic does make it possible to construct a rational treatment plan specific to the patient and the resources available to the treating physician.

**Etiology And Pathophysiology**

Hypothermia is defined as a core temperature less than 35°C (95°F)⁶ and it is classified by severity. (See Table 1.)⁶

These distinctions have marked clinical relevance. In mild hypothermia, all of the body’s normal adaptations to counter heat loss continue to function. The mild hypothermic state is akin to a sympathetic adrenergic surge with increased oxygen consumption, increased minute ventilation, tachycardia, significant vasoconstriction, as well as tremulousness and shivering.

The human body has a circadian temperature

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variation of only 1°C (33.8°F). The body’s regulatory mechanisms are much more adept at cooling than warming, making humans especially susceptible to hypothermia.\textsuperscript{29, 33} Cooling of the human body, as it occurs in accidental hypothermia, causes a spectrum of physiologic effects on each organ system based on the magnitude of temperature change. As hypothermia progresses past the mild stage into moderate and severe, the adaptations to counter heat loss begin to disappear, including the cessation of shivering. Systemic metabolic demands diminish, functionally shutting down and decreasing oxygen consumption. The physiologic effects of hypothermia are most easily understood if broken down by organ system and severity, as summarized in Table 2.

**Cardiovascular System**
Exposure to a cold environment and the subsequent initial attempt to maintain temperature homeostasis causes a sympathetic surge and increased level of circulating catecholamine. This leads to tachycardia and vasoconstriction, initially resulting in an increased cardiac output. As hypothermia progresses, there is a decrease in cardiac pacemaker depolarization with resultant bradycardia and decreased cardiac output; bradycardia occurs in a linear relationship to decreasing core temperature.\textsuperscript{36, 37}

There are numerous cardiac arrhythmias, including atrial and ventricular fibrillation, that occur in the setting of hypothermia. The His-Purkinje fibers, as well as the myocardium, are sensitized and increasingly irritable in the cold patient, most significantly below 30°C (86°F). This irritability, as well as the electrolyte derangements that occur with hypothermia, likely contributes to the etiology of these common cardiac arrhythmias.\textsuperscript{31, 38}

**Respiratory System**
Much like the initial response in the cardiovascular system, the respiratory system is stimulated by exposure to the cold, prompting an increase in respiratory drive. However, with further cooling and subsequent impaired metabolism, the respiratory rate slows significantly. If the hypothermia is profound enough to impair brainstem functioning, the patient may become apneic.\textsuperscript{31, 39}

Other noted effects of cold exposure and subsequent hypothermia on the respiratory system include increased secretions and decreased ciliary motility which can lead to impaired ability to clear secretions. In the context of decreased mental status and impaired cough reflex, hypothermic patients are at increased risk of aspiration and pulmonary infections. Finally, as with many other severe systemic insults, severely hypothermic patients have an increased incidence of acute respiratory distress syndrome (ARDS).\textsuperscript{31, 39, 40}

**Neurologic System**
The overarching theme of initial stimulation followed by subsequent profound decreased metabolism also holds true for brain function in hypothermia. Early in hypothermia, neurons are stimulated by the first 1° drop in core temperature. However, below 35°C (95°F), the cerebral metabolism and thus oxygen requirement decreases by about 10% for every 1° drop.\textsuperscript{31}

**Renal System**
Even those of us who have never experienced significant hypothermia have likely experienced the

<table>
<thead>
<tr>
<th>Table 1. Classification Of Hypothermia</th>
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<tbody>
<tr>
<td>Mild</td>
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<tr>
<td>Moderate</td>
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<td>Severe</td>
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Table 2. Physiologic Effects Of Hypothermia By Organ System And Severity

<table>
<thead>
<tr>
<th>Cardiovascular</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>HR</td>
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<tr>
<td>CO</td>
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<td></td>
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<tr>
<td>Prolonged cardiac conduction intervals, Osborn wave, Afb</td>
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<tr>
<td>VFib asystole</td>
<td>32</td>
<td></td>
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<tr>
<td>Hypotension</td>
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<tr>
<th>Respiratory</th>
<th>Mild</th>
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<th>Severe</th>
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<tbody>
<tr>
<td>RR</td>
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<tr>
<td>Respiratory alkalosis</td>
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<td>VO2</td>
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<tr>
<td>Pulmonary Edema</td>
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<table>
<thead>
<tr>
<th>Neurologic</th>
<th>Mild</th>
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<th>Severe</th>
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<tbody>
<tr>
<td>Ataxia</td>
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<tr>
<td>Apathy</td>
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<tr>
<td>amnesia, dysarthria</td>
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<tr>
<td>Pupils dilate,</td>
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<tr>
<td>pupillary reflex, paradoxical undressing, stupor, LOC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Areflexia, EEG activity; Corneal, OC reflex, CBF; no movement/ pain response</td>
<td>34</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Renal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold diuresis</td>
<td></td>
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<tr>
<td>Cold diuresis, GFR, metabolic acidosis</td>
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<tr>
<td>Oliguria</td>
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<table>
<thead>
<tr>
<th>Metabolic</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>Insulin release/up-take</td>
<td></td>
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<tr>
<td>hyperglycemia 35</td>
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<td></td>
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<tr>
<td>Shivering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No shivering</td>
<td>31</td>
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</tbody>
</table>

Afib: Atrial Fibrillation; BP: Blood Pressure; CO: Cardiac Output; CBF: Cerebral Blood Flow; GFR: Glomerular Filtration Rate; HR: Heart Rate; OC: Oculocephalic; RR: Respiratory Rate; Vfib: Ventricular Fibrillation; VO2: Oxygen Consumption

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phenomenon of cold diuresis after spending a few minutes outside in cold weather. The mechanism of this phenomenon is unclear, but the most commonly purported theory is that initial peripheral vasoconstriction occurring in cold temperatures leads to a central functional hypervolemia. This in turn stimulates a compensatory diuresis.29-31 Derangements in ADH and impaired sodium pump dysfunction may also play a role.36, 41 A concomitant effect of the sodium-potassium pump derangement is impaired potassium secretion; this may result in hyperkalemia, which is often reported in patients with severe hypothermia.36

The hypothermic patient is at risk for significant mixed acid-base problems. In a retrospective review of 135 patients, 25% were alkalotic and 30% were acidotic.42 Early in hypothermia, a patient may have a respiratory alkalosis from increased respiratory drive. As hypothermia progresses this often gives way to a mixed respiratory and metabolic acidosis from both the decreased respiratory drive as well as a lactic acidosis from shivering and impaired oxygenation.31, 36, 43

**Core Temperature Afterdrop**

A physiologic phenomenon frequently noted in both hypothermia and water immersion literature is that of core temperature afterdrop. This term refers to a continued decrease in the hypothermic patient’s core temperature even after they have been removed from the cold environment and rewarming has been initiated.31 The specific mechanisms contributing to afterdrop as well as the extent to which various rewarming strategies can either potentiate or minimize afterdrop are highly debated topics. For more information, see the “Controversies/Cutting Edge” section.

**Differential Diagnosis**

The differential diagnosis for patients with hypothermia can be divided into 3 broad categories based on etiology: increased heat loss, decreased heat production, and impaired thermoregulation. (See Table 3.)

From a functional standpoint, hypothermia can be subdivided by etiology into 3 broad categories: controlled hypothermia, endogenous hypothermia, and accidental hypothermia.44

**Controlled Hypothermia**

Controlled hypothermia is the active cooling of patients; it has been shown to improve neurologic outcomes after cardiac arrest patients.17, 45

**Endogenous Hypothermia**

Endogenous hypothermia is an intrinsic dysfunction in either: a) thermoregulation – such as in CNS trauma or neurodegenerative disorders; b) metabolic derange-

**Table 3. Differential Diagnosis For Hypothermia**

<table>
<thead>
<tr>
<th>Increased Heat Loss</th>
<th>Decreased Heat Production</th>
<th>Impaired Thermoregulation</th>
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<tbody>
<tr>
<td>Cold exposure</td>
<td>Age Extremes</td>
<td>Peripheral failure</td>
</tr>
<tr>
<td>Iatrogenic (eg, cold fluid infusions, exposure)</td>
<td>Hypoglycemia</td>
<td>Neuropathies/spinal injury</td>
</tr>
<tr>
<td>Induced vasodilation</td>
<td>Malnutrition</td>
<td>Diabetes</td>
</tr>
<tr>
<td>Pharmacologic/toxins</td>
<td>Marasmus</td>
<td>Central or neurologic failure</td>
</tr>
<tr>
<td>Dermatologic (eg, erythrodermas, dermatitis, burns)</td>
<td>Kwashiork or extreme exertion</td>
<td>CNS trauma</td>
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<tr>
<td></td>
<td>Endocrinologic failure</td>
<td>CVA</td>
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<td></td>
<td>• Hypopituitarysm</td>
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<tr>
<td></td>
<td>• Hypoadrenalism</td>
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<td></td>
<td>• Hypothyroidism</td>
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<tr>
<td></td>
<td>DKA/AKA</td>
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<tr>
<td></td>
<td>Fatigue/exhaustion/trauma</td>
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</table>

Adapted with permission from Giesbrecht, GG, Wilkerson, JA. Hypothermia Frostbite and other Cold Injuries. P. 38 Copyright ©2006 The Mountaineers
eral vasodilation which leads to convective heat loss. Chronic alcohol consumption impairs the shivering and thermogenesis through hypothalamic degeneration. In addition, hepatic clearance of ethanol and other hepatically metabolized drugs is reduced in hypothermia as hepatic conjugation and detoxification is depressed. Alcohol toxicity can result in hypothermia by a combination of the above plus loss of consciousness and consequent failure to seek shelter.

- **Malnutrition** - Malnutrition increases heat loss due to diminished insulation in the form of subcutaneous adipose tissue and alters thermoregulation.
- **Age** - There is a decline in ability to thermoregulate that occurs with age. The elderly population often has altered thermal perception and autonomic dysfunction that can lead to decreased peripheral blood flow. All of these intrinsic factors are coupled with the fact that the aging population is more prone to concomitant illness and immobility.

## Prehospital Care

Although it is intuitive that a hypothermic patient should be rewarmed, there is little data to guide prehospital care of hypothermic patients. The goal of prehospital care is to rescue the patient, provide modified BLS or ACLS, provide insulation with whatever means available to prevent further heat loss, and rapidly transport the patient to the nearest hospital. The 2005 International Consensus Conference recommends that, “The first aid provider should provide passive warming (using blankets) as feasible for victims of hypothermia.” Victims should be transported to a facility where active rewarming can be initiated. If the victim is in a remote location far from medical help, the first aid rescuer may initiate active rewarming.”

The State of Alaska Cold Injuries Guidelines (most recent edition 2005) is the only guideline available for care of hypothermic patients in the field. It states that BLS/ACLS procedures should not be initiated in the field if:

- core temperature is less than 15°C (59°F)
- chest is frozen/non-compliant
- victim has been submersed in water more than 1 hour
- obvious lethal injury is present
- these procedures significantly delay evacuation to controlled rewarming
- these procedures put rescuers at risk

While these guidelines are helpful and come from a highly experienced group, they have obvious limitations: often times it is impossible to measure core temperatures in the field and the time of submersion is unknown.

Standard thermometers do not typically measure below 34°C (93.2°F), thus the EMS provider cannot know the exact temperature in a hypothermic patient unless they are equipped with thermometers designed to measure lower temperatures. The International Commission for Mountain Emergency Medicine recommends tympanic or esophageal field measurements to maximize accuracy.

Watts et al performed a prospective study on prehospital rewarming of 174 trauma patients to assess techniques for maintaining euthermia. The study had 5 arms comparing no intervention, hot packs, reflective blankets, warmed intravenous fluids, and warmed IV fluids plus reflective blankets. Patients who received hot pack rewarming showed a mean increase in body temperature during transport, while all other groups showed a mean decrease in temperature during transport. Winter storms and rural locations can contribute to long transport times, making the interventions to prevent further heat loss and initiating rewarming all the more crucial.

Hypothermia has been shown to be neuroprotective in post-cardiac arrest patients. As a result, guidelines recommend that most patients be transported for further evaluation and resuscitation in the hospital as opposed to being declared deceased in the field. Recall that the lowest temperature recorded in a child who survived from hypothermia was 14.2°C (57.6°F), and in an adult was 13.7°C (56.7°F). Resuscitation should be continued until the patient is at least 32°C (89.6°F) unless the patient is completely frozen or the mouth and nose are blocked with ice, thus making chest compressions and artificial respirations impossible.

## BLS Treatment

BLS treatment of the hypothermic patient focuses on airway, breathing and circulation just as in their normothermic counterparts. Some modifications are necessary as pulse and respirations are slow and can be difficult to detect. Alongside the ABCs, the initial focus in a very cold patient is to prevent additional heat loss by removing wet clothing and insulating the patient from further exposure.

Providers should assess for breathing and pulses for 30 to 45 seconds to confirm arrest before beginning rescue breathing or CPR. If the patient is not breathing, warm humidified oxygen (from 42°C-46°C or 107.6°F-114.8°F) administered during bag-mask ventilation is recommended if available. Before beginning CPR, providers should assess whether the patient has an organized electrical rhythm (not fibrillation) by placing the patient on a monitor or attaching defibrillation pads. The provider should assume that any organized rhythm is sufficient to provide circulation in the setting of severely reduced metabolism.

There is controversy surrounding CPR and other BLS interventions in the severely hypothermic patient.
Some case reports indicate that CPR may convert the rhythm into fibrillation under these circumstances. Physiologically it is clear that severe hypothermia results in cardiac irritability. It is generally believed that severely hypothermic patients are prone to ventricular fibrillation with movement and therefore should be transported carefully. However, this has not been supported by animal or human studies.

If the patient does convert into fibrillation, the patient should continue to be rewarmed and resuscitated. In a case report published in 2008, a 29-year-old was resuscitated after being rescued from an avalanche with a core body temperature of 21.7°C (71.1°F). The patient was initially breathing spontaneously, and then went into cardiac arrest with ventricular fibrillation during the helicopter evacuation; CPR was not initiated for 15 minutes. The patient was in arrest for a total of 150 minutes, yet ultimately had a complete recovery after rewarming with femoral venoarterial bypass. Follow-up 2 years later showed no deficits from the accident. Despite a lack of large scale prospective studies, cases such as this one provide evidence for the continued treatment in the field in the absence of any signs of life when circumstances reasonably allow.

**ACLS**

**Airway and Breathing**

Patients should be intubated in the field as soon as possible when clinically indicated. Excessive movement should be avoided but not at the expense of securing the airway. In a multicenter survey, endotracheal intubation was performed on 117 hypothermic patients without induction of any dysrhythmias. Intubation enables administration of warm humidified air and reduces the risk of aspiration.

**Circulation**

If the patient does not have a pulse, the provider should check the rhythm before initiating CPR. If the patient has any sort of organized rhythm, the assumption is that there is adequate perfusion. For more information, see the “Controversies” section. There is also some concern (with no strong evidence) that CPR may convert the rhythm into ventricular fibrillation. Doppler ultrasound is emerging as a valuable tool to assess pulses and cardiac activity and its role in the prehospital arena is an active area of investigation. If there is obvious fibrillation on the monitor or ultrasound, 1 defibrillation attempt is appropriate. Although uncommon, patients have been successfully defibrillated below 30°C (86°F) as confirmed by a recent case report of a successful defibrillation of a patient who was 26.5°C (79.7°F). One round of ACLS vasoactive drugs is also appropriate. If the patient does not respond, it is possible that the electricity is not conducting and/or vasoactive drugs are not circulating; in these cases further defibrillation attempts or medication boluses should be deferred until the core temperature is above 30°C (86°F). In 1 case study, a patient’s cardiac activity was re-established with CPR and rewarming from 20°C (68°F). Active rewarming, either externally or internally, using fluids, air, and/or blankets is often difficult in the field due to environmental or equipment constraints. One non-human study did show novel potential techniques of active rewarming in the field as may be the case if a long extraction and transport is necessary: Platts-Mills et al compared 4 techniques of warming IV fluids: with camp stoves, with military MRE heat packs, and with 2 commercially available chemical heat packs. Only heating with the camp stove or MRE pack was successful in achieving the ideal infusion temperature of 35°C to 42°C (95°F to 107.6°F) for rewarming. The main treatment goal for cardiac arrest secondary to hypothermia is aggressive active core rewarming which is generally reserved for in-hospital resuscitation.

**ED Evaluation**

**History**

When a hypothermic patient arrives into the ED, it is important to obtain a focused but thorough history. This information assists in not only diagnosing the hypothermia itself but also in determining any other factors contributing to or complicating the hypothermia. It is important to identify patients with underlying medical conditions predisposing them to hypothermia before attributing the hypothermia to exposure alone. Table 3, page 4 illustrates the many factors that can complicate accidental hypothermia that must be considered while obtaining a patient’s history.

In cold environments, attributing hypothermia solely to exposure may result in potentially missing underlying etiologies. For example, a homeless man who is “found down” presents additional treatment considerations, such as potential metabolic or infectious comorbidities. In the unconscious patient, the only information available may be that from family, friends, rescuers, medical alert bracelets, or patient medical records. It is important to try to determine how long the patient has been down and if there were any other insults prior to the hypothermia such as trauma, hypoxia, alcohol, or drug intoxication.

**Physical**

Hypothermic patients will have varied presentations depending on the degree of hypothermia. There are no studies that have looked specifically at physical findings in hypothermic patients. The clinical picture does not always correlate with the degree of hypothermia; therefore, the grade of hypothermia must be determined by recording the core body...
temperature, and the physical examination should be focused initially to direct management.

The physical examination focuses on mental status, vital signs and physical signs of trauma, illness or poisoning. In mild hypothermia, patients will have vigorous shivering, and cold white skin. Patients in moderate hypothermia may have mental status changes (amnesia, confusion, apathy) plus reduced shivering, slurred speech, hyporeflexia, loss of fine motor skills and / or ataxia. Severely hypothermic patients will have clinical presentations that include combinations of no shivering, cold edematous skin, hallucinations, areflexia, oliguria, fixed dilated pupils, bradycardia, hypotension, pulmonary edema, and sometimes cardiac arrest.6, 28, 64-66

Mental Status
Mental status depression is seen in patients with a core temperature less than 31.7°C (89.1°F). If the patient is above this temperature and mentally depressed, the clinician should consider head injury, infection, toxins, or a metabolic abnormality.67

Vital Signs
In accidental hypothermia without other confounding factors such as toxins or infection, patients should be able to maintain relative hemodynamic stability down to temperatures of 27°C (80.6°F). Below this temperature shivering stops, initially elevated catecholamine levels decrease, the patients’ cardiac output and blood pressure decrease, and severe organ dysfunction begins. This has been demonstrated in a cross-over study with baboons who are cooled to severe hypothermia.68

Temperature: Most standard clinical thermometers do not record temperatures below 34°C (93.2°F). Rectal, esophageal, or bladder thermometers with the ability to measure low temperatures must be used to accurately assess the patient. Rectal and bladder temperature may lag behind actual core body temperature; esophageal thermometers may be more accurate.7,32 One study of 25 hypothermic patients in the OR reported that non-invasive recording (tympanic, oral and axillary) did not accurately indicate core temperature when compared to pulmonary artery, bladder, and esophageal temperatures.69 Another study of 160 patients found tympanic thermometers to be inaccurate compared with core temperature from a pulmonary artery catheter.70 It is clear that some sort of semi-invasive or invasive temperature measuring is necessary to accurately assess the core temperature of a hypothermic patient. In the absence of a pulmonary artery catheter, the authors recommend using esophageal temperature monitoring as it is closest to the core, although there are no studies directly proving its efficacy over rectal or bladder temperature.

Heart Rate: In uncomplicated accidental hypothermia, the patient will be tachycardic until the temperature drops below 29°C (84.2°F) at which point, bradycardia often ensues.32, 71, 72

Blood Pressure: Animal studies suggest that blood pressure rises with progressive hypothermia down to 27°C (80.6°F).73 This is secondary to catecholamine release causing increased vasoconstriction and increased cardiac output. Severely hypothermic patients are often hypotensive secondary to fluid shifts, cold diuresis, and dehydration.6 However, this is not uniform across all patients, as uncomplicated hypothermic patients have been shown in case studies to maintain a normal blood pressure with temperatures down to 25°C (77°F).74 It is crucial to continuously monitor blood pressure for potential hemodynamic collapse that can occur during the rewarming process.5, 32, 75

Respirations: Tachypnea is noted only in mild, early hypothermia during the adrenergic surge while the patient is severely shivering. As the temperature drops below 33°C (91.4°F), respiratory drive diminishes and the respiratory rate drops. Other possible respiratory effects include bronchorrhea and non-cardiogenic pulmonary edema.6, 76

Pulse Oximetry: Pulse oximetry may be difficult to measure in severely hypothermic patients secondary to vasoconstriction. Arterial blood gases (ABGs) may be the only way to assess oxygen perfusion. There have been no direct studies on pulse oximetry in accidental hypothermia. However, some guidance comes from the anesthesiology literature: a study of 10 healthy subjects found a statistically significant lag time in pulse oximetry, noting a hypoxic desaturation when the subjects were mildly hypothermic versus when they were normothermic. In addition, there was decreased failure of forehead pulse oximetry versus standard fingertip reading devices.77

Other Physical Examination Findings
Pupils will often be dilated in moderate and severe hypothermia.6 Consequently, dilated pupils alone, in the absence of decerebrate posturing or lateralizing signs, should not drive hyperventilation or use of mannitol in the hypothermic patient. It is also important to examine the patient carefully for other exposure injuries such as frostbite.

Diagnostic Studies

Laboratory Testing

White Blood Cell Count
The white blood cell (WBC) count may be increased or decreased in hypothermia. An elevated WBC count in hypothermia may be due to leukocyte demargination associated with shivering. It is also possible to see a
decreased WBC count as a result of splenic sequestration during the physiologic stress of hypothermia. The hemoglobin / hematocrit may be elevated due to hemococoncentration secondary to cold diuresis.

**Chemistry Panel**

Electrolyte levels may change frequently during rewarming. In particular, potassium levels will fluctuate as the acid-base balance changes. Sodium, calcium, magnesium, and chloride concentrations do not change significantly, although sodium is often elevated secondary to dehydration. Serum osmolality is also elevated for the same reason. Mild hypothermia is associated with hypokalemia, and severe hypothermia is associated with hyperkalemia from cell death and renal failure. Renal function is abnormal in over 40% of hypothermic patients who require ICU admission.

As the history is often not clear in a patient found down and hypothermic, creatine kinase (CK) should be checked, and the clinician should have a high suspicion of potential renal failure secondary to rhabdomyolysis or acute tubular necrosis. Hypothermic patients may have abnormal liver function tests and reduced clearance of lactic acid due to decreased cardiac output.

**Coagulation Studies**

Severely hypothermic patients are usually coagulopathic due to the temperature dependence of various enzymes in the coagulation cascade. Rohrer et al demonstrated that both prothrombin time (PT) and partial thromboplastin time (PTT) increase with decrease in temperature. Fifteen samples of pooled plasma were tested at 37°C (98.6°F), 34°C (93.2°F), 31°C (87.8°F), and 28°C (82.4°F) demonstrating a statistically significant increase in both the PT and PTT (p < 0.001) as temperature declined. The mean PT at 37°C (98.6°F) was 11.8 seconds compared to a mean of 16.6 seconds at 28°C (82.4°F). In a similar study, Felfernig and colleagues examined the PTT of in vitro plasma and found a 10% increase in PTT between plasma below 35°C (95°F) as compared to plasma at 37°C (98.6°F) (p < 0.05). The reported lab values are often normal as the blood is heated to 37°C (98.6°F) prior to analysis. This is an important consideration in trauma patients where the patient may be exsanguinating despite coagulation studies that appear normal. The coagulopathy is self-limiting and resolves with rewarming.

A meta-analysis of 24 published randomized trials comparing blood loss/transfusion requirements in normothermic patients versus hypothermic patients corroborates the significance of coagulopathy with hypothermia. Even mild hypothermia (< 1°C or 33.8°F) significantly increases blood loss by approximately 16% and increases the relative risk for transfusion by approximately 22% (3%–37%).

**Blood Gases**

Blood gas values are notoriously difficult to interpret in the hypothermic patient and provide a source of controversy. Blood gas analyzers warm the blood sample to 37°C (98.6°F); this increases the partial pressure of the gases thereby increasing the hydrogen ion concentration of the sample. The result is a corrected value which falsely elevates the CO₂ and lowers the pH. Therefore, it is our preference to use an uncorrected ABG to guide clinical management. Correcting a patient’s acid-base balance using the lab-corrected ABG could result in exacerbating an acidosis and worsen outcomes by hindering cerebral blood flow, hindering coronary blood flow, and potentiating arrhythmogenicity. Practically speaking, this can be accomplished by omitting the patient’s temperature from the blood gas lab requisition.

The reality is that hypothermic patients can have many types of acid-base disturbances: metabolic acidosis due to lactate, a respiratory alkalosis from the cold blood, a respiratory acidosis from the hypoventilation, or any combination of those. Therefore, it is best to simply treat the actual uncorrected ABG, with a goal of an uncorrected pH of 7.35 and a pCO₂ of 40 mm Hg while looking for underlying contributing factors.

**Ethyl Alcohol Level**

Generally, patients with altered mental status have their blood alcohol level tested, especially if they are hypothermic since alcohol or drug intoxication is a frequent cause of, or contributor to, hypothermia.

**Urine Toxicology**

As with alcohol, patients with altered mental status should be considered for urine toxicologic screening. Depending on the hospital, the panel may be limited but may help in a patient with altered mental status of undetermined etiology. The clinician must consider the fact that urine toxicologies are often positive long after the intoxication is resolved.

**Other**

If the hypothermic patient fails to respond to rewarming techniques or there is no clear source of cold exposure, the emergency physician should consider testing for other possible underlying etiologies (e.g., hypothyroidism or adrenal insufficiency).

**Diagnostic Imaging**

**Radiography**

Hypothermic patients with altered mental status are inherently at risk for aspiration pneumonia and should have a screening chest radiograph (CXR).

**Ultrasound**

There are no studies specifically looking at the use of ED ultrasound in hypothermic patients. However, ED bedside ultrasound has an established role in
evaluating for contributing causes of altered mental status: A FAST examination evaluates for free fluid indicating trauma or eroding intra-abdominal processes. If any of these examinations are positive, further studies and consults can be expedited. The heart can also be examined for pericardial effusion, contractility, and wall motion abnormalities.

CT Scan
CT imaging is not clearly indicated for the hypothermic patient. However, it can be considered, especially in the patient who continues to have altered mental status after they are warmed above 32°C. Once the severely hypothermic patient is stabilized, directed CT scan, based on patient signs and symptoms, can be considered and can help reveal underlying infection or trauma.

Other Diagnostic Studies
Electrocardiography (ECG)
The heart of a hypothermic patient will have decreased spontaneous depolarization of pacemaker cells, prolonged action potential, and slowed myocardial impulse conduction; all of which result in abnormal repolarization. These changes are manifest in the numerous ECG changes observed in hypothermic patients, including but not limited to: prolonged intervals (PR, QRS, and QT), premature beats, atrioventricular blocks, ST depressions and elevations, bradycardia, and atrial and ventricular arrhythmias.

The most common ECG finding is the Osborn wave, seen in approximately 80% of hypothermic patients. (See Figure 1.) Also known as the J-wave, the Osborn wave is a positive deflection at the QRS-ST junction. In a retrospective review of 59 patients with hypothermia, 51 of these patients, or 86%, were noted to have an Osborn wave on initial ECG. In 1 of the few prospective trials in the accidental hypothermia literature, Vassallo et al looked at 43 patients with hypothermia over 2 years; 37 patients had evidence of the Osborn wave on their initial ECG.

The evidence is not clear on what exactly prompts the electrocardiographic formation of a J-wave. One hypothesis is that hypothermia-induced ion fluxes result in delayed depolarization or early repolarization of the left ventricle. Another theory is that there may be an unidentified hypothalamic or neurogenic factor.

The Osborn wave can be seen at any degree of hypothermia, from mild to severe. There is some evidence that the absolute size of the J-wave is correlated to the temperature, and it tends to resolve as the patient is rewarmed. While this unusual ECG change is sometimes considered pathognomonic for hypothermia, it can be seen in normothermic patients, often in the context of cardiac arrest and hypercalcemia.

Treatment
Once the diagnosis of hypothermia is made, the physician must decide how to resuscitate the patient based on the severity of hypothermia and the resources available. The physician should also be on the lookout for underlying illnesses or toxins and treat them early and aggressively. The clinical pathway on page 10 provides a treatment algorithm based on the best available evidence.

Rewarming
There are 4 general types of rewarming with numerous modalities within each category. (See Table 4, page 11.)

Passive Rewarming
In a mildly hypothermic patient with a core temperature greater than 32°C (89.6°F), passive rewarming is recommended. The goal of passive rewarming is reducing convective, conductive, and radiant heat loss. Complicating factors must be considered since passive rewarming requires intact thermoregulatory mechanisms, normal endocrine

![Figure 1. ECG Of J-Wave (Osborn Wave)](Image is courtesy of William Brady, MD, University of Virginia.)
Hypothermia Clinical Pathway

The evidence for recommendations is graded using the following scale. For complete definitions, see back page. Class I: Definitely recommended. Definitive, excellent evidence provides support. Class II: Acceptable and useful. Good evidence provides support. Class III: May be acceptable, possibly useful. Fair-to-good evidence provides support. Indeterminate: Continuing area of research.

This clinical pathway is intended to supplement, rather than substitute for, professional judgment and may be changed depending upon a patient’s individual needs. Failure to comply with this pathway does not represent a breach of the standard of care.

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Cold Patient
- Check core temp
- Remove cold clothing
- Insulate to prevent further loss
- Minimize patient jostling
- Keep horizontal
- Treat disorders

Temperature < 35°C (95°F) = Hypothermic

Check responsiveness

Responsive
- Handle gently
- Cardiac monitor

Check temperature
- Mild (32°C to 35°C (89.6°C to 95°C))
- Moderate (28°C to 32°C (82.4°C to 89.6°C))
- Severe (<28°C (82.4°C))

- Active external rewarming
- Passive rewarming
- Active internal rewarming
- Active external rewarming
- Extracorporeal blood warming (CAVR) (Class II)

Unresponsive
- Patient frozen solid
- Ice in nose/mouth
- Core temperature < 10°C (50°F)
- Submerged >1 hour
- Obvious lethal injury

Intubate gently (Class I)
Hold resuscitation

Check pulse

Pulseless

Pulse present?

Consider holding CPR (Class III)
Consider pacing. (Indeterminant)

Check temperature

PEA
Bradycardia
VFib
Asystole
Shock x1
ALCS drugs x 1

Check rhythm

Organized
Vfib/Asystole

Defer drugs

Aggressive rewarming/active internal warming (Class III) until 30°C (86°F) then re-evaluate.

Aggressive rewarming/active internal rewarming (Class III) until 30°C (86°F) then re-evaluate.

*Signs of Life
- Spontaneous Ventilation
- Spontaneous movement/sound
- Audible beat on auscultation
Table 4. Rewarming Methods

<table>
<thead>
<tr>
<th>Category</th>
<th>Methods</th>
<th>Rewarming Rate (°C/h)</th>
<th>Rewarming Rate (°F/h)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive external</td>
<td>Blankets</td>
<td>0.5</td>
<td>32.9</td>
<td>Insulation. Only effective if shivering intact. Only effective if shivering intact. In 1 study half as effective as a heating pad.</td>
</tr>
<tr>
<td></td>
<td>Space blanket</td>
<td>0.5</td>
<td>32.9</td>
<td></td>
</tr>
<tr>
<td>Active external</td>
<td>Forced air rewarming device</td>
<td>1-2.5</td>
<td>33.8-36.5</td>
<td>Risks of burns, temperature after-drop, and rewarming hypotension.</td>
</tr>
<tr>
<td></td>
<td>Warm blankets, heating pads</td>
<td>Variable</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Radiant heat</td>
<td>Variable</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot water bottles</td>
<td>Variable</td>
<td>Variable</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative-pressure rewarming</td>
<td>Variable</td>
<td>Variable</td>
<td>Not readily available.</td>
</tr>
<tr>
<td></td>
<td>Hands and feet in warm water</td>
<td>Variable</td>
<td>Variable</td>
<td>Easy to do, not sufficiently studied.</td>
</tr>
<tr>
<td></td>
<td>Warm water immersion</td>
<td>2-4</td>
<td>35.6-39.2</td>
<td>Difficult to monitor patient, risk of temperature after-drop and rewarming hypotension.</td>
</tr>
<tr>
<td>Active internal</td>
<td>Warm (42°C or 107.6°F) and/or humidified air</td>
<td>0.5-1.2</td>
<td>32.9-34.2</td>
<td>Low heat transport capacity, minimizes after-drop when used with active external methods.</td>
</tr>
<tr>
<td></td>
<td>Warm (42°C or 107.6°F) intravenous fluids</td>
<td>Variable</td>
<td>Variable</td>
<td>More effective with large volumes, fluid overload possible, central venous IVF’s effective in dogs up to 65°C (149°F).</td>
</tr>
<tr>
<td></td>
<td>Mediastinal, gastric, colonic, thoracic, peritoneal or bladder lavage</td>
<td>Variable</td>
<td>Variable</td>
<td>Limited data, risk of mucosal injury, Invasive, risk of aspiration with gastric lavage.</td>
</tr>
<tr>
<td></td>
<td>Peritoneal dialysis</td>
<td>1-3</td>
<td>33.8-37.4</td>
<td>Combine with heated oxygen, 6 to 10 L/hour heated to 45°F (113°F).</td>
</tr>
<tr>
<td></td>
<td>Open thoracotomy lavage</td>
<td>up to 8 (median 2.95)</td>
<td>up to 8 (median 2.95)</td>
<td>Highly invasive, 71% survival in 1 study.</td>
</tr>
<tr>
<td>Extracorporeal</td>
<td>Hemodialysis and hemofiltration</td>
<td>2-3</td>
<td>35.6-33.8</td>
<td>Available in most facilities, requires adequate blood pressure, trained dialysis nurse needed.</td>
</tr>
<tr>
<td></td>
<td>Continuous arteriovenous rewarming (CAVR)</td>
<td>3-4</td>
<td>33.8-39.2</td>
<td>Rapid initiation, trained perfusionist not required, less available, requires ad equate blood pressure.</td>
</tr>
<tr>
<td></td>
<td>Cardiopulmonary bypass</td>
<td>7-10</td>
<td>44.6-50</td>
<td>Provides full circulatory support, allows oxygenation, less available, requires trained perfusionist, delays in initiation. Fastest overall rapid warming method: 3 to 4 times faster than other active core rewarming methods.</td>
</tr>
</tbody>
</table>
Active External Rewarming

In patients with mild hypothermia who are not responding to passive rewarming or patients with moderate hypothermia, active external rewarming is indicated. Active external rewarming involves applying heat directly to the skin; it assumes circulation is intact to return warmed blood to the core. In a crossover study of 8 healthy patients, active external rewarming was shown to be twice as fast as passive rewarming.95 Forced warm air devices are a very effective method of active external rewarming and allow the provider to continually monitor the patient. Forced air rewarming devices warm the patient 1°C (33.8°F)/h to 2.5°C (36.5°F)/h and when placed only over the patient’s trunk can minimize the risk core afterdrop.92, 93 One prospective, randomized trial looked at 16 patients re-warmed from temperatures below 30°C (86°F) using cotton blankets compared with forced air rewarming devices. The study found that patients re-warmed using the forced air rewarming device rewarmed 1°C (33.8°F)/h faster than patients warmed with cotton blankets only.92 Another study compared rewarming of 8 patients using forced air rewarming compared with inhalation rewarming and spontaneous rewarming. The patients were cooled on 3 separate occasions and meperidine was administered to prevent shivering. Forced air re-warming warmed patients 2°C (35.6°F)/h faster than either of the other methods.95 The American Society of Anesthesiologists recommends the use of forced air rewarming devices to treat hypothermia and maintain normothermia in post-operative patients during emergence and recovery.96 One prospective study by anesthesiologists compared forced air rewarming to no intervention intra-operatively and found that forced air rewarming effectively maintained normothermia.97 Another meta-analysis showed that intraoperative normothermia is maintained most effectively with forced air-rewarming.98 One 1999 retrospective study showed that 15 severely hypothermic patients were successfully re-warmed to 35°C (95°F) using forced air rewarming.99

Water blankets, warm blankets, warm water bottles, heating pads, and warm water immersion are other effective methods of active external rewarming. Care must always be taken to prevent dermal heat injury from these techniques. External heating should be done with temperatures between 40°C (104°F) to 45°C (113°F) to be effective and prevent burning.100 With all of these methods, the patient should ideally have their trunk warmed first and extremities warmed later in order to prevent core-afterdrop and rewarming acidosis. For more information, see the “Controversies/Cutting Edge” section. Both of these phenomena have been anecdotally related to poor outcomes.31, 75 For these reasons, it is recommended that the core be warmed first, and that active external rewarming be combined with internal rewarming using warmed IV fluids and warm humidified air. It is important to assure adequate volume resuscitation to minimize rewarming complications.29 The exception to the core rewarming first rule is with rewarming of arteriovenous anastomosis, the next section.100

Active Internal Rewarming

In patients with severe hypothermia or patients with cardiovascular instability, active internal rewarming is the recommended modality. Active internal rewarming consists of warm IV fluids, warm humidified inhaled air, and warm fluid lavage of body cavities. Extracorporeal rewarming, which is the most effective type of active internal rewarming, is discussed separately in the following section.

There are no studies comparing the active internal rewarming modalities. Warm humidified air and warm IV fluids are 2 effective rewarming methods with little side effects that should be used on all hypothermic patients when available. Warm humidified oxygen (to 42°C or 107.6°F) increases core body temperature by 0.5°C (32.9°F)/h to 1.2°C (34.2°F)/h and decreases evaporative heat loss from respiration.101

Warm IV fluids (preferably 40°C or 104°F) will rewarm a patient with minimal complications. The rate of warming depends on the rate of infusion. Studies on beagles have shown warm IV fluids, up to 60°C (140°F), to be effective in warming hypothermic patients if administered centrally but comparative studies have not been done on humans.102 The concern in fluids warmed to 60°C (140°F) is endovascular damage. Peripherally, fluids should be no warmer than 40°C (104°F). The authors believe that centrally administered fluids at warmer temperatures would be an effective technique for rewarming patients, but this needs to be further investigated to minimize risk of complications. IV fluids are best heated using a blood warmer, given that microwave warming can create dangerous temperature differentials within the fluid bag.103 It is important to monitor the patient for fluid overload and most importantly pulmonary edema during rapid infusions.

In the absence of extracorporeal rewarming, active internal rewarming can also be accomplished via lavage of body cavities. Closed thoracic lavage involves placement of 2 thoracostomy tubes. The first is placed in the midaxillary line at the second to third intracostal space for warm saline infusion and the second is placed lower in the traditional mid clavicular line to allow continuous outflow. (See Figure 2.) A literature review looked at 14 patients treated with open thoracotomy or thoracostomy tubes for active re-warming in severely hypothermic patients with cardiac arrest. All of the patients were successfully restored to normal sinus rhythm after a median time of 120 minutes. Eight patients survived without sequelae, 1 patient survived with neurologic deficit, and 5 patients died.23 Another case series of 5 mildly hypothermic patients reported that all 5
were successfully warmed via pleural lavage and discharged to their homes without sequelae. 107

Open thoracic lavage, has been shown to raise the core body temperature up to 8°C (46.4°F)/h. 106 A retrospective review of 11 patients in hypothermic cardiac arrest reported a 71% (7 patients) survival rate in patients who received a thoracotomy in the ED (5 of these patients later underwent cardiopulmonary bypass); four patients went straight to the OR for cardiopulmonary bypass and none of these patients survived. 106 This does not imply that open thoracotomy is superior to cardiopulmonary bypass as the study was non-matched and not randomized. It does, however, provide evidence to the potential efficacy of open thoracotomy lavage. It is a highly invasive procedure with risk for further morbidity or mortality. The authors cannot advocate the use of this procedure, given there is no clear evidence that it is a superior warming technique to other less invasive methods.

**Extracorporeal Rewarming**

The most effective method of rapidly rewarming patients is extracorporeal blood warming. In light of the more recent literature supporting the benefit of hypothermia post arrest, it remains to be seen if it is better to slowly correct the temperature of hypothermic patients post arrest. Regardless of the long-term morbidity question, extracorporeal blood warming is definitively the fastest way to re-warm a patient. Hemodialysis is probably the most readily available extracorporeal rewarming technique and will raise the core temperature 2°C (35.6°F)/h to 3°C (37.4°F)/h. 108-111 Hemodialysis requires adequate blood pressure. Other methods that require blood pressure are continuous arteriovenous rewarming (CAVR) or continuous venovenous rewarming (CVVR). (See Figure 3). CAVR is relatively simple, requiring minimal equipment and set-up, and uses the patients’ blood pressure to drive the blood through a small counter current heat exchanging device. 109 CAVR warms the core temperature 3°C (37.4°F)/h to 4°C (39.2°F)/h. 32 CVVR, which is technically easier for the emergency physician to set up and is less invasive, has also been shown to effectively resuscitate severely hypothermic patients in studies. 108,111 A randomized controlled trial using swine found CAVR to offer a more rapid rate of rewarming than CVVR, but both methods were superior to less invasive methods. 113 In patients who are bradycardic and hypotensive, 1 case report on 2 patients demonstrated the efficacy of transcutaneous pacing to maintain the patient’s blood pressure during CAVR. 114

In patients who are hypotensive, another method which has been shown to be efficacious in canine models is high-flow venovenous rewarming (HFVR) using bypass. This needs to be studied in humans before it can be implemented but may prove to be useful as it would be easier to set up than cardiopulmonary bypass. 20 Cardiopulmonary bypass raises the core body temperature 7°C (44.6°F)/h to 10°C (50°F)/h, supports the circulation, and avoids cardiac trauma through CPR or open thoracotomy massage. (See Figure 4, page 15) 115,116 There have been no prospective randomized controlled trials looking at the efficacy of cardiopulmonary bypass versus other rewarming methods, but there are several published case reports that show positive outcomes after cardiac arrest.

A Finnish study showed a 61% survival rate in

**Figure 2. Thoracic Lavage**

This image is used with permission from Auerbach, Paul S. Auerbach: Wilderness Medicine 5th Edition, Figure 5-11. Copyright ©2007 Mosby Elsevier

**Figure 3. Continuous Arteriovenous Rewarming**

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23 patients after a mean arrest time of 70 minutes using cardiopulmonary bypass. All 23 patients had completely arrested and required cardiovascular support as well as rewarming.117 Another study had a survival of 15 of 32 patients with a mean temperature of 21.8°C (71.2°F) and a mean down time before cardiopulmonary bypass was initiated of 141 minutes. In a 7 year follow-up of these patients, none had significant sequelae.119 A study of Mount Hood hypothermia survivors showed similar success with cardiopulmonary bypass.120 In patients who have cardiac arrest from hypothermia and can no longer circulate their own blood, cardiopulmonary bypass effectively circulates and rewarms the blood.

There are many case reports attesting to the efficacy of cardiopulmonary bypass.121 One case report published in 2007 demonstrated complete recovery of an asystolic hypothermic (to 23.8°C or 74.8°F) 2-year-old after cardiopulmonary bypass.122 Cardiopulmonary bypass is 3 to 4 times faster at rewarming than other active internal warming methods and maintains oxygenation and blood flow for the patient who has arrested.123 Thus, in severely hypothermic patients with cardiac arrest, this is an effective method of resuscitating the patient. Pleural lavage also provides effective treatment under these circumstances. There have been no studies comparing the 2 modalities directly.

A review of multiple studies supports therapeutic hypothermia to 32°C (89.6°F) to 34°C (93.2°F) for 12 to 24 hours post cardiac arrest.115 There is no definitive evidence to advise only rewarming hypothermic patients to this range post-arrest as the patients have had the neuroprotective effects of hypothermia during the time they were pulseless.

It is unclear whether this should be extrapolated to recommend maintaining patients who have arrested secondary to hypothermia at 32°C (89.6°F) to 34°C (93.2°F) for 12 to 24 hours post cardiac arrest.

Although cardiopulmonary bypass is the fastest method of rewarming, there is evidence to indicate that this invasive type of treatment may be unnecessary in patients with a pulse. One study in Vienna published in 2002 suggested a conservative approach is successful in achieving normothermia in patients with deep hypothermia with or without stable hemodynamics. The study looked at rewarming 36 patients with a median temperature of 25.6°C (78.4°F) using extracorporeal rewarming methods such as cardiopulmonary bypass and continuous arteriovenous devices are expensive and only available in limited facilities. More readily available and less expensive treatments must often be implemented.

Cost-Effective Strategies

1. **Extracorporeal rewarming methods such as cardiopulmonary bypass and continuous arteriovenous devices are expensive and only available in limited facilities. More readily available and less expensive treatments must often be implemented.**

   Warmed humidified air, warmed IV fluids and a forced air rewarming devices are all readily available with little overhead cost. Invasive rewarming including thoracic lavage, peritoneal lavage, and gastric lavage are relatively accessible but time- and resource-consuming. In a patient with severe hypothermia with full cardiac arrest, the patient is unlikely to regain cardiac function until they are warmed to at least 30°C (86°F). In this circumstance, thoracic lavage or cardiopulmonary bypass is necessary.

2. **Invasive rewarming methods may not always be necessary in select populations.**

   At times, some groups of patients with significant comorbidities may be best treated with less aggressive rewarming methods. In-hospital mortality of severe accidental hypothermia in patients with comorbidities is high, and these patients may be best served by correcting the underlying conditions.124,125 If the patient does not respond to empiric treatment with non-invasive rewarming, active internal rewarming should be initiated. It should also be noted that although studies have shown urban patients can be successfully rewarmed with non-invasive methods, the influence of the rewarming strategy on late in-hospital mortality remains unclear.

3. **The most effective way to minimize the time and cost involved in hypothermia treatment is education and prevention.**

   Elderly people need to be educated about keeping warm in the winter. Many cities have resources that help keep at-risk populations warm in the setting of cold and wet weather. Homeless people are particularly at risk, and substance abuse can not only pre-dispose a person to hypothermia but will also cause a person to be kicked out of a shelter. This is clearly a national problem that contributes enormously to healthcare dollars spent treating hypothermic patients. Another population that is at risk is those who recreate outdoors. As the prevalence of outdoor recreation increases, people need to be educated about layering clothing with insulative, wind-proof, and waterproof layers. Education about survival and mountaineering skills will also reduce incidence. There are many outdoor schools and programs that teach this, but it is also easy to give a quick reminder to patients in the ED.
warmed infusions, inhalation rewarming, and forced air rewarming. Although 92% of the patients were successfully rewarmed to normothermia, in-hospital mortality was 42% but was largely related to comorbidities. Thus, it appears patients can be adequately rewarmed with conservative methods but unfortunately the influence of the rewarming strategy on late in-hospital mortality remains unclear.124

Other Treatment Considerations

Patients with uncomplicated hypothermia should have a rapid rate of rewarming. Patients with poisoning or infection often rewarm slowly due to decreased intrinsic capacity for thermogenesis (< 1°C or 33.8°F/hour). Achievement of normothermia in these patients does not necessarily prevent death. Thus, in addition to rewarming the patient, other general treatment principles must be considered with a focus on detecting and treating underlying illness.125 If a bedside glucometer is not available, the patient should be administered dextrose. Hypothermic patients will mask signs and symptoms of hypoglycemia and may also have depleted glycogen stores. Thiamine may also be given empirically. Alcohol or drug intoxication is often associated with or is the cause of hypothermia and must be addressed.23, 108 The presence of an elevated alcohol level in an altered hypothermic patient should raise the suspicion of aspiration. In the absence of additional history, a high alcohol level will alert the physician to the potential for withdrawal.

Most patients are severely dehydrated from cold diuresis and events leading up to their presentation, and they will have elevated serum sodium and osmolality. Patients who have been hypothermic for over 45 minutes will often require fluid administration because the vascular space expands due to vasodilatation.76 There is no evidence to support the use of empiric steroids unless there is a history of adrenal insufficiency or the patient fails to re-warm adequately despite aggressive rewarming techniques.

High-risk groups such as the homeless, neonates, and the elderly should be empirically treated with broad spectrum antibiotics. In a prospective observational study of 96 patients presenting to the ED with hypothermia, rewarming rates were found to reflect a patient’s intrinsic capacity for thermogenesis. Patients who were also infected responded poorly to rewarming.125 In a retrospective study of 59 adults admitted to Bellevue Hospital, New York, between 1968 and 1979 because of hypothermia due to exposure, 24 (41%) had 32 serious infections. Nine of these infections were not diagnosed at the time of admission and had increased morbidity and mortality.79 Peripheral blood cultures should be drawn prior to consideration of empiric antibiotic therapy.

While treating the patient, it is important to observe the patient’s response to the therapy. Whatever rewarming method is chosen, the patient should be monitored during and after rewarming. Possible complications of rewarming are listed in Table 5. One placebo controlled study of 20 patients showed that desmopressin partially reverses hypothermia-induced impairment of primary hemostasis in vitro and may be potentially useful in improving hemostasis in hypothermic patients with bleeding where immediate rewarming is difficult or undesirable. Whole blood from the 20 patients was cooled to 32°C (89.6°F) and clotting time was measured compared to the same blood at 37°C (98.6°F). Clotting time was then measured after administration of various amounts of desmopressin compared to saline placebo, and researchers found that desmopressin improved clotting time. This needs to be looked at in vivo but provides a potentially life-saving therapy in bleeding hypothermic patients where rapid rewarming is not immediately available.25

Special Circumstances

Anoxic Injuries

Evidence has shown that patients who have sustained asphyxia prior to hypothermia (ie, from

Table 5. Potential Complications From Rewarming The Severely Hypothermic Patient

- Core temperature after-drop
- Rewarming related hypotension
- Hypoglycemia, paralytic ileus
- Bladder atony
- Bleeding diathesis
- Rhabdomyolysis
- Acid-base balance
- Ventricular fibrillation
- Changes in electrolytes
- Hyperkalemia and hypophosphatemia

Figure 4. Cardiopulmonary Bypass

This image is used with permission from Auerbach, Paul S. Auerbach: Wilderness Medicine 5th Edition, Figure 5-15. Copyright ©2007 Mosby Elsevier
1. “The nurse wasn’t able to obtain/didn’t record a temperature.”
Temperature is a vital sign and should be given almost the same weight as blood pressure or respirations. However, in a medical code or trauma, this vital sign can be easily overlooked in the hustle and bustle of ABC’s, ACLS, or ATLS. Temperature can slip through the cracks all the more easily in a hypothermic patient whose temperature cannot be established with a standard clinical thermometer, which does not read below 34°C (93.2°F). Ensure that a low-reading rectal, bladder, or esophageal thermometer is readily available to accurately assess temperature. Finding a low temperature in a trauma or cardiac arrest patient changes the appropriate course of action.

2. “The patient didn’t have a pulse, so we initiated CPR.”
Beware of falling into a routine ACLS protocol with a patient who feels cold to the touch. Even if the patient does not have a pulse, CPR may not be warranted. Check the temperature and assess the cardiac rhythm first. While there is still controversy surrounding this issue, there is some evidence that starting CPR in the severely hypothermic patient with an organized rhythm may precipitate fatal ventricular dysrhythmias. Given the decreased metabolic demands of the hypothermic patient, any organized rhythm, (even if severely bradycardic) may be a perfusing rhythm.

3. “The patient seemed to be protecting his airway, so we decided to hold off on intubating him.”
Avoid delays in intubating the unresponsive hypothermic patient. Hypothermic patients with altered mental status are at high risk for aspiration and developing subsequent aspiration pneumonia. While esophageal temperature probe placement does not require concomitant intubation, it can be easily facilitated in the intubated patient for continuous temperature measurement without interference from rewarming techniques. Intubation allows for safe and successful active external rewarming via warmed humidified air running through the ventilatory circuit.

4. “The patient was in PEA arrest and didn’t respond to 4 rounds of ACLS drugs, so I called the code.”
If the patient’s core temperature is less than 32°C (89.6°F), it is not appropriate to stop resuscitation. Continue resuscitation until the hypothermic patient has been rewarmed to above 30°C (86°F) to 32°C (93.2°F). This may result in a prolonged resuscitation times; however, heed the adage that ‘the patient is not dead until he is warm and dead’. The severely hypothermic patient will often be refractory to defibrillation and vasoactive medications due to poor circulation and vasoconstriction. If the first round of defibrillation or medications is not successful in converting the rhythm or re-establishing a pulse, it is appropriate to deviate from standard ACLS, holding further rounds until after the patient has been adequately rewarmed.

5. “The patient was warming up well, but all of a sudden became hypotensive and crashed. I don’t know what happened.”
The exact mechanism of ‘core afterdrop’ is controversial; however, it is a well documented phenomenon that patients may transiently deteriorate in the midst of rewarming, either from a decrease in core temperature, a decrease in blood pH or from hypotension and shock. While the exact mechanism is still unclear, the expert consensus recommends preferential core rewarming, with active techniques in the case of moderate to severe hypothermia. In addition, it is important to ensure that the patient has been sufficiently volume resuscitated to maintain adequate blood pressure.
over 1 hour. The pediatric population is particularly susceptible to drowning accidents. In a retrospective review of 12 pediatric patients with cold water submersion and hypothermia with cardiac arrest, the outcome was better with lower core temperatures at the beginning of extracorporeal circulation. Nine out of the 12 survived with the lowest temperature survived 16°C (60.8°F). The time in the water was unknown. In children, resuscitation should be continued until the patients are rewarmed even in submersion injuries. Cardiopulmonary bypass is the best method of resuscitation, where available. In adults, further studies are needed to establish treatment guidelines following asphyxiation events.

**Trauma**

Studies have shown the protective aspects of hypothermia on head injured patients, cardiac patients, and patients in shock. Therefore, it would seem that hypothermia would be protective in a trauma climate, or weather. Hypothermia should remain on the differential for every medical code and trauma patient and every patient with altered mental status. While the absolute death rate from hypothermia is highest in traditionally colder climates such as Alaska, Montana, and Wyoming, and 83% occur from October to March, there are still significant deaths in traditionally mild climates such as Arizona and South Carolina.

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**Risk Management Pitfalls For Management Of Hypothermia (Cont. from page 16)**

6. “I tried everything and the temperature wouldn’t budge.”

If the patient is not responsive to passive rewarming techniques, it is likely that they have lost the capacity for thermogenesis, and active rewarming must be initiated. However, when the patient fails to respond to active external or internal methods of rewarming (ie, raising their core temperature by less than 1°C [33.8°F]/hr), it is important to consider other underlying contributing factors, including hypothyroidism, adrenal insufficiency, or infection. Prospective studies have indicated that hypothermic patients who are slower to rewarmed, both passively and actively, are more likely to have an underlying infection, which also gives them a higher mortality rate. In addition, hypothermia appears to impair neutrophil function, predisposing patients to infection.

7. “The patient was rewarmed to 36°C (96.8°F) but remained unresponsive.”

If a hypothermic, unresponsive patient continues to have significantly altered mental status after his core temperature has been rewarmed to above 32°C (89.6°F), it is crucial to explore other possible etiologies for the altered mental status. Hypothermic patients seen in the emergency department are often trauma victims, hypoglycemic, acutely intoxicated, or septic. Diabetic and alcoholic patients frequently remain comatose at higher temperatures than patients without these comorbidities. Do not wait until the patient has been fully rewarmed to reassess and consider other underlying issues.

8. “I just moved to Arizona and started practicing at the local city hospital, so I didn’t even think that the patient found down on the street corner could have been hypothermic; I just assumed he was a drunk, needing to metabolize.”

Accidental hypothermia can occur in any season,
patient. Although this is still a controversial subject, evidence actually shows that hypothermia is associated with poor outcomes in trauma patients with bleeding. Hypothermia in the trauma patient is a type of secondary, unintentional hypothermia; it is both a marker of and a contributor to poor outcome. Trauma patients whose core temperatures drop below 32°C (89.6°F) have a 39% mortality based on a retrospective analysis of the 2004 national trauma data bank.\textsuperscript{131} Trauma patients become hypothermic from many different reasons including cold ED and OR temperatures, cold fluid resuscitation, open body cavities, and lack of thermogenesis due to tissue hypoxia. The proposed etiologies for increased morbidity and mortality include dysfunction in platelets, induction of coagulopathy, and the worsening of acidosis. Every effort should be made to minimize temperature drop and initiate rewarming when dealing with the bleeding trauma patient in the ED.

It may therefore seem counter-intuitive that a new area of trauma resuscitation research is focusing on the induction of severe hypothermia in the trauma patient. Critical and arresting trauma patients are now being placed on bypass upon their arrival in the ED and cooled down to profoundly hypothermic temperatures.\textsuperscript{146} While this work is still in its nascent stages, it may allow salvage of otherwise unrecoverable injuries.

### Controversies/Cutting Edge

#### Controversies

**CPR In Hypothermic Patients**

The American Heart Association Recommendations from 2005 state that if there is any doubt whether a pulse is present, compressions should be started.\textsuperscript{8} However, all experts agree that palpating a pulse in the cold, stiff hypothermic patient is extremely difficult. In addition, given the profoundly decreased metabolic demands of the hypothermic patient, there is growing evidence that any organized rhythm is probably a perfusing rhythm. It is likely that the organized pulseless electrical activity (PEA) or severe bradycardia provides enough cardiac squeeze to perfuse the hypothermic body. An organized rhythm can be taken as a sign of life.\textsuperscript{29}

There are very mixed opinions on the degree to which movement, such as CPR, can precipitate ventricular fibrillation. However, it is well documented that ventricular fibrillation in the setting of hypothermia can be refractory to defibrillation attempts.\textsuperscript{32} The hypothermic heart is often unresponsive to cardioactive drugs. Additionally, drug metabolism is reduced and levels in peripheral circulation can become toxic. For this reason, the American Heart Association advises that cardiac drugs be withheld until the core body temperature is at least 30°C (86°F) and be given with longer inter-

#### Cutting Edge

**Warming Fluids In A Conventional Microwave**

Microwaves certainly are not cutting edge and are not regularly used to rewarm IV fluids when resuscitating patients. However, some facilities do not have IV fluid warmers and others may not have sufficient numbers if multiple patients are being resuscitated. Thus, warming fluids in a microwave offers an inexpensive solution. Several studies have demonstrated the efficacy of warming IV fluids in a conventional microwave before administering them to the patient.\textsuperscript{103, 136, 137} One study cautioned about the danger of warming the fluids too much if the microwave is not adequately calibrated.\textsuperscript{138} The fluids should not be warmed above 40°C (104°F) as there is a risk of endovascular damage.\textsuperscript{136} Leaman et al studied warming PRBC in a conventional microwave and found it caused hemolysis.\textsuperscript{103} The bottom line is that it appears conventional microwaves offer an inexpensive and easy way to warm IV fluids before administering them, but there is potential danger if they are not used carefully. Microwaves do not provide uniform heating, thus it is imperative that the fluids are shaken and their temperature measured prior to infusing to prevent endovascular damage.

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Bretylium tosylate 5 mg/kg has been anecdotally shown to be useful in the treatment of hypothermia induced ventricular fibrillation in a case study but it has never been validated.\textsuperscript{134}
Arteriovenous Anastomoses Rewarming

A newly described method of active external rewarming is recruiting the arteriovenous anastomoses by submerging the hands and feet in water heated to 45°C (113°F). This allows warmed venous blood to return to the core.\textsuperscript{139} One study looked at rewarming patients from 34.3°C (93.7°F) comparing shivering vs. submersion of the distal extremities in 42°C (107.6°F) or 45°C (113°F) water. The rewarming rate in the 45°C (113°F) was 9.9°C (49.8°F)/h versus 6.1°C (42.9°F)/h in the 42°C (107.6°F) group and 3.4°C (38.1°F)/h in the shivering cohort. The rectal temperature, however, lagged considerably behind the esophageal and aural canal so large temperature gradients may still exist.\textsuperscript{139} There is also a warmed negative pressure device that can be applied to the forearm that accomplishes the same thing. This is an application that is still being investigated.\textsuperscript{139} This method would also seem to exacerbate the core afterdrop phenomena, although adequate fluid resuscitation may be the solution to preventing this rather than initial core rewarming, as previously discussed.

A promising rewarming method recently reported for the first time in a case report is using an endovascular warming device to warm a severely hypothermic patient. The endovascular temperature control systems are the same systems that are used to induce resuscitative hypothermia for comatose survivors or cardiac arrest. The system successfully rewarmed the patient by 2.8°C (37°F)/h and was ultimately removed once the patient's temperature reached 37°C (98.6°F). The patient had good hemodynamic recovery although care was ultimately withdrawn secondary to poor neurologic prognosis. Endovascular rewarming devices are being placed in increasing numbers of EDs for therapeutic cooling and offer a less invasive, more effective alternative to pleural lavage in facilities that do not have extracorporeal rewarming methods available. The systems will be familiar to more and more emergency physicians as they become more widespread for therapeutic cooling and will not require a team to run the machine. The only clear drawback compared with cardiopulmonary bypass is the patient must have a pulse.\textsuperscript{140}

Disposition

Hypothermia is a severe illness, with numerous possible complications as a result of the cascade of physiologic abnormalities that occur. The vast majority of hypothermic patients will require hospital admission, often to the intensive care unit. In a retrospective analysis of 47 patients admitted to the ICU with a diagnosis of accidental hypothermia, the only variable that was correlated with an increase in mortality was the use of vasopressors in the resuscitation of the patient. The study identified several prognostic factors for the 18 patients who died compared with those who survived including age, systolic blood pressure, blood bicarbonate level, SAPS II score, the use of mechanical ventilation, the use of vasopressor agents, rewarming time, the discovery of the patient at home, and the initial temperature. The initial temperature did not influence vital outcome. Only the use of vasoactive drugs (odds ratio, 9; 95% confidence interval, 1.6 to 50.1) was identified as a prognostic factor in the multivariate analysis. Put simply — shock, requiring vasoactive drugs, is an independent factor for mortality while initial temperature is not, according to this retrospective analysis.\textsuperscript{131}

The select group of patients stable for discharge home after rewarming are the mildly hypothermic patients, with an initial temperature above 32°C (89.6°F). Even these patients should not be discharged if they were resistant to passive external rewarming, do not have a clear cause for their hypothermia (such as excessive cold exposure, intoxication, etc), or there is any indication of an underlying complication, such as infection or thyroid abnormalities.

All other hypothermic patients, falling into the moderate to severe categories, are automatic hospital admissions, usually to the intensive care unit given their need for continuous monitoring. Rewarming is typically a lengthy process, often not completed prior to their transfer out of the emergency department. Even the most rapid invasive methods such as CAVR or cardiopulmonary bypass only rewarm a patient 4°C (39.2°F)/h to 7°C (44.6°F)/h.\textsuperscript{32} In addition, hypothermic patients need close monitoring for the myriad of complications that may occur during or following rewarming. Some of the most common include delayed hypotension, arrhythmias, hypoglycemia, hyperkalemia, bleeding diathesis, rhabdomyolysis, extremity injuries, and infection/sepsis.

A patient who is slow to respond to rewarming techniques should be tested and treated empirically for other contributory causes for their hypothermia. The most common of these includes myxedema coma, adrenal insufficiency, and infection. The most pressing issue with regards to the disposition of the hypothermic patient is often the length of resuscitation. Because of the pathophysiology of hypothermia, it is possible to successfully resuscitate a patient who initially has no pulse and minimal cardiac activity. As a result, a hypothermic patient should be fully resuscitated, even if they do not have any clear signs of life, until their core temperature has been elevated to > 30°C.\textsuperscript{76, 142} The exceptions, as previously noted, include other obvious lethal injuries, a clear do not resuscitate order, or a severely frozen patient for whom resuscitation is not possible.\textsuperscript{31}
Summary

Hypothermia can affect anyone, anywhere, at any time of year. While the weak and compromised are certainly at greater risk, the powerful forces of weather can easily take the life of even the youngest and healthiest of patients. From biblical times to modern popular television shows, hypothermic patients are depicted as miraculously ‘returning from the dead’ in the hands of the physician. While this outcome is possible, it requires thoughtful diagnosis and proper treatment.

Unfortunately, despite significant interest in hypothermia, there is limited evidence to support clinical decision making. The majority of patients can be rewarmed using warmed IV fluids and forced warm air. Those who do not respond must be further explored for the overlooked underlying causes. In patients who deteriorate, evidence points to potential great success with even delayed cardio-pulmonary bypass. Finally, the old adage continues to be backed up by the best evidence available. “The hypothermic patient is not dead until he is warm and dead.” This may place large demands on the physician and department for resuscitation time and resources; however, the seemingly miraculous successful resuscitation not only makes this demand worthwhile, but also keeps hypothermia a captivating topic in emergency medicine practice.

Case Conclusions

Remembering that a patient is not dead until he is warm and dead, the 50-year-old “John Doe” who was 25°C (77°F) was defibrillated once and given epinephrine once without return of pulses or an organized cardiac rhythm. CPR was continued; transferring the patient for cardio-pulmonary bypass was not possible and it would take at least two hours to initiate dialysis. A decision was made to place chest tubes for closed pleural lavage in addition to using warmed IV fluids. The patient was rapidly rewarmed to 30°C and regained pulses. Aggressive pleural lavage was continued, broad-spectrum antibiotics were initiated as the patient was high risk, and the patient was transferred to the ICU for close monitoring. Unfortunately, due to his myriad of comorbidities, the patient ultimately expired 4 days later.

The patient in Wyoming was intubated gently to protect her airway and ventilated with warm humidified air. Before arrival to the ED, the physician set up to use the forced air warmer and warm IV fluids; a recently purchased arteriovenous extracorporeal blood warming device was also prepared. Upon arrival, the patient’s esophageal temperature was 28°C (82.4°F); she still had pulses so the continuous arteriovenous rewarming was initiated. The patient warmed rapidly, was extubated the next morning, and was discharged after 24-hour observation.

The patient in Jacksonville had altered mental status and a temperature of 32°C (89.6°F). Underlying comorbidities were suspected and broad-spectrum antibiotics were initiated while warming was started with a forced air rewarming device and warm humidified oxygen. A positive urinalysis for nitrates and leukocytes suggested a diagnosis of urosepsis which prompted the early goal directed therapy protocol. The patient warmed to the point of being febrile but recovered and was discharged back to the nursing facility the following week.

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the reference for study and the number of patients in the study, will be included in bold type following the reference, where available.


86. Kjaergaard B, Bach P. Warming of patients with accidental hypothermia using warm water pleural lavage. Resuscitation. Feb 2006;68(2):203-207. (Case report; 5 cases)


1. Mild hypothermia (32-35°C or 89.6°F-95°F) should be treated with:
   a. Active internal rewarming
   b. Passive rewarming if shivering intact
   c. Active external rewarming
   d. Extracorporeal rewarming

2. Resuscitation should be continued in a hypothermic patient even if the patient:
   a. Is frozen
   b. Was submerged for over an hour
   c. Has been receiving CPR for over an hour
   d. Has sustained lethal injuries

3. A patient should have a normal mental status above what temperature?
   a. 25°C (77°F)
   b. 28°C (82.4°F)
   c. 32°C (89.6°F)
   d. 34°C (93.2°F)

4. Which type of extracorporeal rewarming does not require that the patient have a perfusing blood pressure?
   a. Continuous arteriovenous rewarming
   b. Hemodialysis
   c. Continuous venovenous rewarming
d. Cardiopulmonary bypass

5. All undifferentiated hypothermic patients should be given which of the following?
   a. Stress dose steroids
   b. Thiamine
   c. Dextrose
   d. Antibiotics

6. Core afterdrop is a problem with which of the following?
   a. Is frozen
   b. Has sustained lethal injuries
   c. Has been receiving CPR for over an hour
   d. Extracorporeal rewarming

7. The most common ECG finding in hypothermia is which of the following?
   a. Peak T waves
   b. J-wave (Osborn wave)
   c. Prolonged QT
   d. AV block

8. If a patient is rewarming at a rate less than 1°C/hour, which of the following is the most common etiology?
   a. Intoxication
   b. Infection
   c. Hypothyroidism
   d. Adrenal insufficiency
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**Class I**
- Always acceptable, safe
- Definitively useful
- Proven in both efficacy and effectiveness
- High-quality meta-analyses
- Study results consistently positive and compelling

**Class II**
- Safe, acceptable
- Probably useful

**Class of Evidence:**
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case control studies
- Less robust RCTs
- Results consistently positive

**Class III**
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

**Class of Evidence:**
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

**Indeterminate**
- Continuing area of research
- No recommendations until further research

**Class of Evidence:**
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling


**Coming In Future Issues**

**Male Urogenital Emergencies**

**Cervical Spine Injuries**

**Musculoskeletal MRI**

**Facial Anesthesia**

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**Target Audience:** This enduring material is designed for emergency medicine physicians, physician assistants, nurse practitioners, and residents.

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Accidental Hypothermia: An Evidence-Based Approach
Mulcahy, A, Watts, M. January 2009, Volume 11; Number 1
This issue of Emergency Medicine Practice reviews the evidence and current understanding of the pathophysiology, clinical assessment, and treatment options for maximizing outcomes in accidental hypothermia.

EVIDENCE-BASED CLINICAL RECOMMENDATIONS FOR PRACTICE

<table>
<thead>
<tr>
<th>Key Points</th>
<th>References*</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental hypothermia can occur in mild climates, and even indoors, especially among high risk populations such as the elderly, the homeless, or in the setting of acute intoxication or trauma.</td>
<td>1,2</td>
<td>Hypothermia occurs in a wide variety of environmental settings and is complicated by multiple patient co-morbidities.</td>
</tr>
<tr>
<td>Standard thermometers do not read below 34°C (93.2°F). Diagnosis of hypothermia (temperature &lt; 35°C (95°F) taken with a rectal, bladder, or esophageal probe) requires a low-reading thermometer.</td>
<td>12</td>
<td>The International Commission for Mountain Emergency Medicine recommends tympanic or esophageal field measurements to maximize accuracy.</td>
</tr>
<tr>
<td>The initial focus in a very cold patient is to prevent additional heat loss by removing wet clothing and insulating the patient from further exposure.</td>
<td>8</td>
<td>Generally, BLS and ACLS protocols should be followed, although there is some controversy surrounding BLS interventions in the severely hypothermic patient.</td>
</tr>
<tr>
<td>Active external rewarming, such as a forced air rewarming device, warmed humidified air, and warm IV fluids is sufficient for most hypothermic patients.</td>
<td>96</td>
<td>The American Society of Anesthesiologists recommends the use of forced air rewarming devices to treat hypothermia and maintain normothermia in post-operative patients during emergence and recovery.</td>
</tr>
<tr>
<td>If a hypothermic patient has been rewarmed to &gt; 32°C (89.6°F) but continues to have an altered mental status, look for other underlying etiologies such as infection or toxic ingestion.</td>
<td></td>
<td>Do not wait until the patient has been fully rewarmed to re-assess and consider other underlying illnesses.</td>
</tr>
<tr>
<td>If a patient is resistant to rewarming techniques, consider other causes such as hypoglycemia, infection, myxedema coma, or adrenal insufficiency.</td>
<td>125</td>
<td>In addition to rewarming the patient, other general treatment principles must be considered, with a focus on detecting and treating underlying illness.</td>
</tr>
<tr>
<td>“A patient is not dead until they are warm and dead.” Continue resuscitation until the patient is rewarmed to 30°C (86°F) to 32°C (89.6°F).</td>
<td>3,4</td>
<td>The lowest initial temperature recorded in a child who survived from hypothermia was 14.2°C (57.6°F), and the lowest recorded temperature in an adult was 13.7°C (56.7°F).</td>
</tr>
<tr>
<td>Resuscitation may be withheld only if the patient is frozen solid, there is an ice-occluded airway, there is a clear “Do Not Resuscitate” order, there are other obvious lethal injuries, or the patient was documented to be submerged for over an hour.</td>
<td>31, 76, 142</td>
<td>Except in these instances, a hypothermic patient should be fully resuscitated, even if they do not have any clear signs of life, until their core temperature has been elevated to &gt; 30°C.</td>
</tr>
<tr>
<td>Even if an unresponsive patient does not have a pulse, consider holding CPR if the patient has an organized rhythm on cardiac monitor.</td>
<td>32</td>
<td>There is controversy surrounding CPR and other BLS interventions in the severely hypothermic patient. Some case reports indicate that CPR may convert the rhythm into fibrillation under these circumstances.</td>
</tr>
<tr>
<td>If a patient in asystole or ventricular fibrillation does not respond to initial vasooactive medication or defibrillation, respectively, hold further rounds and actively rewar the patient, considering more invasive active rewarming such as cardiopulmonary bypass.</td>
<td>32</td>
<td>It is well documented that ventricular fibrillation in the setting of hypothermia can be refractory to defibrillation attempts.</td>
</tr>
</tbody>
</table>

* See reverse side for reference citations.
REFERENCES


11. Delaney KA, Vassallo SU, Larkin GL, Goldfrank LR. Rewarming rates in urban patients with hypothermia: prediction of underlying infection. Acad Emerg Med. Sep 2006;13(9):913-921. (Prospective observational study; 96 patients)


CLINICAL RECOMMENDATIONS

Use The Evidence-Based Clinical Recommendations On The Reverse Side For:

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