Accidental Hypothermia

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Abstract: Accidental hypothermia has produced many cases of intact survival even after prolonged cardiac arrest, but it is also often fatal. In recent years, alterations in resuscitation care that sometimes confused or discouraged resuscitation teams have largely been supplanted by an emphasis on safe, rapid, effective rewarming. Rewarming decisions and even the simple recognition of hypothermia remain challenging. This review seeks to update and demystify some of these challenges.

Key Words: accidental hypothermia, rewarming, resuscitation, infants

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TARGET AUDIENCE

This article is aimed at health care providers who see children and adolescents in acute care and emergency settings. These may include physicians, nurses, and midlevel providers. Pediatricians, family practitioners, and physicians in training may find the information relevant.

LEARNING OBJECTIVES

After completion of this CME article, the reader should be better able to:

1. Classify common causes of hypothermia beyond exposure and immersion.
2. Categorize the stages of hypothermia with their approximate temperature thresholds.
3. Treat hypothermia using the appropriate methods and indications for active external rewarming, active core rewarming, and circulatory rewarming.

Accidental hypothermia is common, and children may be more prone to hypothermia than adults, but it is not so common that clinicians always feel comfortable with the challenges of its treatment. In the past, many alterations were recommended in standard care. These sometimes caused confusion and controversy and may have left emergency providers feeling at times that hypothermia was an insoluble puzzle.

Today, more emphasis is placed on effective and safe rewarming. However, this creates its own challenges. Even the recognition of hypothermia is surprisingly difficult. Yet the reward for meeting these challenges may at times be remarkable recoveries for patients.

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A complete discussion of accidental hypothermia is both fascinating and complex.[1] Along with defining the causes and stages of hypothermia, this review will focus especially on practical aspects of the care of moderate to severe accidental hypothermia in children. We will not discuss perioperative, neonatal, or therapeutic hypothermia, or focal cold injuries such as frostbite.

Hypothermia is defined as a core temperature below 35°C (95°F) and may be further classified by temperature into mild, moderate, severe, and profound stages (Table 1). Exact temperature cutoffs in guidelines vary slightly,[1,2] but temperature measurement may be imprecise, and each patient will manifest features slightly differently, so exact cutoffs are somewhat arbitrary.

The classic signs of hypothermia such as shivering and cold and pale skin seen in mild hypothermia are due to compensatory mechanisms. Moderate hypothermia then spans the narrow range of temperatures where these compensatory mechanisms fail, along with metabolism and thermoregulation. Classic compensatory signs of hypothermia disappear. Thus, severe hypothermia is not only more dangerous but may also be harder to recognize.

For clinicians given temperatures in Fahrenheit, temperatures conversion is available on computers and handheld devices as well as the Internet. It may be helpful to remember that 95°F corresponds to 35°C, and 82°F to 28°C, the respective thresholds of mild and severe hypothermia.

ETIOLOGY

Five physical processes rob the body of heat: radiation, conduction, convection, evaporation, and respiration. Human skin is an excellent radiator, and radiant heat travels at the speed of light. Thus, radiation is a large source of heat loss even at room temperature, especially with patient exposure during resuscitation. Conduction, low in air, becomes extremely high in contact with water. Convection and evaporation, low indoors, are markedly increased by wind and wet and exposed skin. Respiratory heat loss increases with exertion, cold dry air, and altitude.

Hypothermia is not limited to northern climates. Cold-related deaths may be twice as common as heat-related deaths in the southern US.[3] The causes of hypothermia are many (Table 2). Near drowning and immersion are common environmental causes. Overexertion, fatigue, exhaustion, hunger, dehydration, poor equipment, and impaired judgment also sometimes contribute to hypothermia in backcountry recreation. Transport and resuscitation are common iatrogenic causes of hypothermia.

Although we often think of hypothermia as related to outdoor mishaps, any cold exposure, even indoors, may lead to hypothermia, as may any trauma, severe illness, or disruption of the skin surface such as burns. Intoxication may lead directly to cold exposure, as when inebriation leads to unconsciousness in a cold environment, but many drugs and toxins also suppress thermogenesis and thermoregulation. These include ethanol as well as barbiturates, opioids, benzodiazepines, phenothiazines, and others.

Even mild hypothermia may signal hypothalamic crises, sepsis, or profound hypoglycemia. Unexplained hypothermia may

TABLE 1. Stages of Hypothermia*

Core Temperature °C (°F)	Stage	Possible Signs
32–35 (90–95)	Mild	Shivering, pallor, acrocyanosis Increasing clumsiness, slurred speech
28–32 (82–90)	Moderate	Compensatory signs disappear Confusion
25–28 (77–82)	Severe	Flushing, muscle rigidity, edema Stupor
<25 (<77)	Profound	Clinical appearance of death Coma

*Signs may vary in onset; temperature thresholds are arbitrary.

be a sign of child abuse[4] and may arise from many mechanisms, including cold water baths as punishment, forced water intoxication, neglect in a cold setting, or inaccurate reporting of time intervals after critical neurologic injury.

PATHOPHYSIOLOGY

Hypothermia may at times have protective effects, but we must see it as primarily harmful. The human tolerance of hypothermia may be linked in part to the evolution of endothermy. Humans may survive core cooling by as much as 20°C but may die with core heating by as little as 5°C.

With a high ratio of body surface area to mass, children are at most physical risk of hypothermia. Yet for the same reason, children may be more likely than adults to achieve hypothermic protection against brain anoxia due to rapid cooling before cardiac arrest.

The physiologic changes in mild hypothermia are those of compensation, such as vasoconstriction, and attempts to generate heat, such as shivering and increased metabolism. In the face of ongoing heat loss, these mechanisms cannot be maintained. With the onset of moderate hypothermia at approximately 32°C, the body's attempts to combat cooling begin to fail. Physiologic changes typically include respiratory depression, vasodilation, depletion of blood volume, cardiac instability, circulatory insufficiency, and depressed mental status. Patients may lapse from confusion into stupor, and rescuers may note irrational or combative behavior and even paradoxical undressing.

As the compensatory mechanisms fail, metabolism itself is suppressed by cold, slowing by approximately 6% for each 1°C decrease in core temperature, so that, by 28°C, the basal metabolism may be half the normal rate.

In severe hypothermia, below approximately 28°C, all body systems begin to fail, with severe impairment or absence of ventilation, circulation, and consciousness. Two particular changes in physiology are linked to the problem of death after rescue, which is alarmingly common in hypothermia. These are the problem of afterdrop and rewarming shock.

Afterdrop refers to the continued decline in core temperature even after the patient is removed from a cold environment. In part, this is due simply to ongoing conduction of heat out of the core, but it is promoted further by patient exertion, by cold (room temperature) intravenous (IV) fluids, and by warming the periphery before the core, leading to the dumping of cold, acid blood back into the central circulation before cardiac function and adequate blood volume are established.

Rewarming shock is especially profound and lethal. Failure to replete the circulating volume during rewarming is a major cause of commonly observed death after rescue or during resuscitation.

The blood volume in hypothermia is under triple threat because of extravasation, cold-induced thickening of the blood, and a profound "cold diuresis." This diuresis is caused initially by artifactual overload at central volume receptors because of peripheral vasoconstriction and later by cold-induced failure of renal concentrating function. Rewarming and vasodilation of the periphery before the core may worsen this collapse of blood volume by bringing cold, acidotic blood back to the core and increasing demands on a collapsed cardiovascular system. A further circulatory insult occurs when rescue from water immersion removes a considerable hydrostatic squeeze on the limbs that had been maintaining blood volume in the core circulation.

This profound hypovolemia potentiates the cardiovascular collapse seen in hypothermia. Cardiac output is also reduced by vasodilation, by decreased myocardial contractility, and by bradycardia. Cardiac conduction abnormalities are numerous. The most important, ventricular fibrillation and asystole, are common end point rhythms in severe hypothermia.

Many other changes in physiology have been observed in hypothermia. Common features may include hyperkalemia, hypoglycemia or hyperglycemia, metabolic acidosis or alkalosis, and coagulopathy with or without thrombocytopenia.

CLINICAL PRESENTATION AND RECOGNITION

The diagnosis of hypothermia requires only a low-reading thermometer and a high index of suspicion. Clinicians may be surprised that hypothermia is frequently missed. It would seem that a drop in body temperature of 5°C to 20°C would be easy to detect. Clinical thermometers, however, often read no lower than 34°C (94°F), the final temperature noted in many cases of death attributed to other causes. Table 1, which lists typical signs of hypothermia, suggests one reason that serious hypothermia can be missed. As the core temperature declines from mild to severe hypothermia, paradoxical signs replace the obvious features of chilling. Flushing replaces cyanosis. Flushed cold skin not be palpably colder than vasoconstricted normal skin. Shivering is replaced by muscle rigidity due to dysfunction of actin-myosin bundles. Muscle rigidity may be severe; many patients with core temperatures well above freezing have been described as frozen stiff.

Even in the absence of asystole, the profound bradycardia, hypotension, and hypoventilation of hypothermia, accompanied by unresponsiveness and fixed dilated pupils, may often

TABLE 2. Some Causes of Hypothermia

Cold, wet, or wind exposure
Immersion, submersion, near-drowning
Shock, sepsis, severe illness
Trauma, transport, resuscitation
Burns, weeping dermatoses
Alcohol, barbiturates, opioids, benzodiazepines, phenothiazines, others
Hypoglycemia
Hypothyroidism, hypoadrenalism, hypothalamic and pituitary lesions
Anorexia nervosa; malnutrition (tropical hypothermia)
Child abuse, water intoxication

lead to an inappropriate declaration of death. Clinicians expect death to produce a cold appearance, so hypothermia is especially easy to overlook in the patient taken for dead. These are the same patients, however, who sometimes make the most remarkable recoveries.

Because severe hypothermia is easy to overlook, the core temperature should be measured and monitored in all children with critical illness or critical injuries. A low-reading thermometer should be used in critical care, especially if standard thermometers indicate a temperature lower than 35°C.

Oral and axillary temperatures are unreliable in hypothermia. Even rectal temperatures, however, may fail to reflect core temperature. The rectal temperature can lag far behind core temperature during cooling and rewarming.[5] Modern clinical monitors can track temperatures via attached flexible probes. If rectal temperature is measured, the use of flexible probes inserted at least 10 cm (4 in) gives more accurate information. Bladder temperature may be less prone to artifact, and temperature-sensing urinary catheters are available in children's sizes. The most meaningful sites to place temperature probes in hypothermia, however, are the esophagus and nasopharynx, which reflect cardiac and brainstem temperatures, respectively.

EVALUATION AND MANAGEMENT

Once hypothermia is recognized, a point-of-care test for serum glucose should be obtained, as should serum electrolytes, serum urea nitrogen and creatinine, a serum lipase, a complete blood cell count, and coagulation studies. Other laboratory studies should be obtained as indicated for assessment of trauma, intoxication, or infection and for other possible causes of hypothermia.

Blood gas measurement from a capillary source may be misleading in hypothermia because the capillary beds are cold and stagnant. Venous blood gases may suffice to assess carbon dioxide and acid-base status. Pulse oximetry may be useful, but only if an adequate waveform can be established. Blood gases are probably best interpreted without correction for temperature. Corrected values leave the patient more acidotic and hypercarbic than uncorrected results.[6,7]

A 12-lead electrocardiogram (EKG) should be obtained, and continuous cardiac rhythm monitoring is vital because the cardiac rhythm may change spontaneously. Among many other cardiac abnormalities, ventricular fibrillation (VF) and asystole can develop due to cold alone. Conversely, rewarming has been noted to spontaneously convert asystole to VF and VF to normal sinus rhythm.[8] Other EKG changes may include bradycardia; widened EKG intervals including the PR, QRS, and QT; and many other dysrhythmias. Most of these will correct with rewarming.

Clinicians have at times recognized hypothermia owing to the presence of a J-wave or Osborn wave (Fig. 1) on the EKG. This upward deflection at the J point is strongly suggestive of hypothermia but is not present in all cases.

Radiographic studies may be obtained as indicated to assess trauma, infection, or other clinical concerns.

TREATMENT

In the past, various resuscitation measures were altered in hypothermia. Such changes at times caused confusion and disagreements during resuscitation. Modern approaches deemphasize many of these controversies. Recent American Heart Association guidelines[2] stress that, "… management of cardiac arrest due to hypothermia focuses on aggressive active core rewarming techniques as the primary therapeutic modality."

In fact, the most important measure may simply be not to withhold care from victims of hypothermia. Although hypothermia is harmful in general, patients with moderate to severe hypothermia (core temperature <32°C) may also benefit from cerebral protection, so that standard indicators of nonviability must be modified. Hypothermic patients without circulation have made intact recoveries from core temperatures as low as 14°C, submersion for at least 66 minutes, several hours of transport without cardiopulmonary resuscitation (CPR), CPR for as long as 6.5 hours, and resuscitation for up to 9 hours.[5,9–11] Yet patients continue to be pronounced dead in severe hypothermia despite potentially survivable injuries.

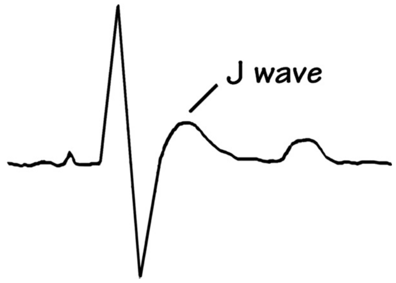

FIGURE 1. The J-wave or Osborn wave is sometimes but not always seen on the electrocardiogram in hypothermia.

Some efforts have been made to explore laboratory markers of nonviability.[12,13] These efforts may be useful in mass casualty triage, but threshold levels have not been defined.[14,15] Likewise, although survival after prolonged submersion only occurs in icy cold water lower than 40 to 50°C,[16,17] in practice, it is often difficult to establish either submersion time or water temperature.

A particular problem is the perception that aggressive rewarming or ongoing life support in hypothermia might lead to seriously impaired survival. This does not seem to be the case. Among a series of 46 adults with severe hypothermia and cardiac arrest, 32 were selected for circulatory rewarming. Of these, 15 had long-term survival. None of the survivors were left with serious neurologic complications.[18] Patients have made intact recoveries after many hours of rescue, resuscitation, and rewarming and after days of aggressive ongoing care.[5,9,11,19]

"No one is dead until they're warm and dead," is still a useful guideline. This can be taken to mean that, except in the presence of obvious lethal injury, the declaration of death should be withheld until the core temperature has reached 32°C or greater for 30 or more minutes. At that temperature, little further cerebral protection against anoxia exists.

Rewarming Therapy

The modern focus on effective but safe rewarming presents clinicians with both intellectual and logistic challenges. One simple step is the avoidance of further cooling. Once hypothermia is recognized, cold or wet clothing should be removed, patient exposure should be minimized, and further sources of cooling should be avoided.

At approximately 21°C, room temperature air and IV solutions are colder than all but the coldest hypothermia patients are. Although sometimes considered core rewarming in the past, heated IV solutions and heated airway humidity do not contribute enough heat to cause rewarming but are basic measures that prevent further cooling. They are thus safe for all patients. Intravenous and airway humidity warmers can be set to deliver temperatures of 40 to 44°C.

Effective delivery of warm IV solutions, however, requires trauma-suite fluid warmers that use short, large-gauge, insulated or countercurrent tubing. Airway warming equipment is typically available from the respiratory therapy department.

As heat loss is being controlled, rewarming therapy should be chosen according to the degree of hypothermia and the presence or absence of spontaneous circulation. Past debates centered on appropriate rewarming rates, but slow rewarming has no proven advantage in children. Evidence, in fact, suggests that rapid rewarming accompanied by aggressive patient support and fluid resuscitation may produce the best results. Many of the most remarkable reported recoveries also involve the most rapid rewarming rates.[15,18–20]

Rewarming therapy was traditionally divided into passive, active external, and core rewarming methods. Passive rewarming consists of applying insulation (blankets) in a warm environment. Although useful in transport, and perhaps adequate in patients with very mild hypothermia, this method offers no benefit in children and has several disadvantages, offering no support and requiring spontaneous thermogenesis. Thus, active rewarming should be planned. The central question is whether this should be external or core rewarming.

External Rewarming

Active external rewarming applies heat to the skin and depends mainly on the circulation to warm the core. Active external rewarming is widely available and is often indicated for mild and moderate hypothermia. Although this was once a standard approach to all rewarming, it carries several important caveats. External heat applied to underperfused skin has been associated with thermal injury.[21,22] External rewarming in cases of arrested circulation may be so slow as to produce extremely long resuscitations. External rewarming can also promote rewarming shock and afterdrop, which are common causes of death during resuscitation. Experts thus often withhold external rewarming in cases of absent circulation, especially in severe hypothermia. A practical approach to the detection of spontaneous circulation may simply be careful palpation for a central pulse.

When other methods are unavailable, reports of successful active external rewarming even in severe hypothermia continue to appear. Although many involve patients who had some preserved circulation, others note successful rewarming in the face of cardiac arrest.[4,23] External heat is sometimes directed to the trunk, axillae, and groin and withheld from the extremities, in an effort to decrease afterdrop and the return of cold, acid blood to the circulation.

Many successful reports of external rewarming in severe hypothermia involve forced air rewarming. This method, which blows heated air onto the patient via perforated, inflatable tubes or blankets, seems quite effective and seems to cause little apparent afterdrop.[4,24–26]

On the basis of these reports, some rewarming protocols prefer forced-air rewarming to heated water blankets, hot packs, or heat lamps.[27] If forced-air rewarming is not available, these other methods may still be useful.

Core Rewarming

Active core rewarming is preferred to external rewarming in hypothermic patients with arrested circulation, not only because it is more effective but also because it lessens afterdrop and rewarming shock. Active core rewarming is also indicated when hypothermia is unresponsive to external rewarming measures. Core rewarming techniques can be achieved in any emergency department. Heated gastric lavage at 40 to 44°C lavage, common in the past, raised concerns of aspiration of lavage solution. Heated lavage has also been directed to the peritoneum, colon, and bladder. Evidence suggests, however, that left pleural lavage may be the most effective irrigation method.[23,28,29] The left pleural space is chosen because it bathes more of the myocardium.

Pleural lavage can be achieved in many EDs. Two chest tubes are placed: one for infusion and one for drainage; ideally, these are directed somewhat anterior and posterior, respectively. Irrigation involves continuous drainage rather than a dwell time; care should be taken that drainage is effective and uninterrupted.

A major logistic challenge for all warm lavage methods is a copious and continued supply of heated fluids. Resuscitation planners may consider using high-flow IV warmers or the tub heating systems used in peritoneal dialysis. One adult report of successful resuscitation noted pleural lavage with 75 L of heated tap water.[30]

Open thoracotomy lavage, at times used in the past, has no advantage and removes the mechanics of closed-chest CPR. Direct cardiac massage is undesirable because the cold myocardium is rigid and inelastic.

Circulatory Rewarming

The most rapid and effective core rewarming methods involve circulatory rewarming with external circuits, either by cardiac bypass or by extracorporeal membrane oxygenation (ECMO). In severely hypothermic patients with absent or severely compromised circulation, especially with VF and asystole, other core methods are often ineffective. These same patients, however, are the subjects of many reports of intact neurologic survival after circulatory rewarming.[10,18,20,27] Although some series involve adults, others involve children younger than 2 years.[10,31] The only limitation in younger children may be the placement of large-bore cannulae. The need for anticoagulation, a relative contraindication in cases of severe trauma, is not absolute.[32]

Circulatory rewarming methods not only provide the most rapid rewarming but also restore circulation while providing oxygenation, hemodilution, and patient support. They restore the blood volume and warm the heart before rewarming the periphery, thus preventing afterdrop and rewarming shock.

The rapid provision of circulatory rewarming will require prior consultation and planning with a cardiac bypass or ECMO team. Such preplanned protocols have been shown to be useful in children's hospitals.[27] Hospitals without pediatric bypass or ECMO teams will want to develop transfer protocols to centers where such teams are available, recalling that patient transport for at least 3 hours and CPR for at least 6.5 hours have been associated with successful outcomes.[9,11]

Table 3 summarizes one possible approach to selecting rewarming methods based on the stage of hypothermia and the presence or absence of circulation. Many patient and facility factors, however, will govern the choice of technique, and successful resuscitation has been reported using a large array of methods. Centers without circulatory rewarming or the ability to transfer a patient should not be reluctant to rewarm victims of severe hypothermia using available methods.[4]

Other methods of rewarming including hemodialysis, arteriovenous and venovenous shunts, and intravascular methods have been described and are useful in selected cases.

Failure to rewarm is an indication to use more aggressive core rewarming methods. We note again not only that prolonged resuscitation does not preclude survival from severe hypothermia but also that, once the core temperature reaches approximately 32°C, little further cerebral protection can be expected. In this era when induced hypothermia may be used in post-arrest care, some may choose to decrease rewarming measures above approximately 32°C, while still closely monitoring core

TABLE 3. A Possible Way to Match Rewarming Methods to Stages of Hypothermia and the Presence or Absence of a Pulse*

Stage	Pulse	Preferred Method; Other Options
Mild	Present	Forced air rewarming; other active external methods
Moderate	Present	Forced air rewarming; other active external methods
Severe	Present	Forced air rewarming; heated left pleural lavage
Severe	Absent	Circulatory rewarming; heated left pleural lavage
Profound	Present or absent	Circulatory rewarming; heated left pleural lavage

*These are only suggestions. Clinicians must consider many patient and facility factors to determine the method or methods to be used. Numerous methods have been used successfully. Failure to rewarm is an indication to move to a more aggressive method.

temperature, preventing further cooling, and instituting other post-resuscitation care. Overwarming is to be avoided in all cases.

Rescue and Transport

Emergency physicians will be consulted about the prehospital care of hypothermia victims. Because temperature measurement in the field may be difficult or unavailable, physicians controlling such rescues will recall that hypothermia may occur not only in cold environments but also with trauma, immersion, outdoor exposure, intoxication, and critical illness.

The possibility of hypothermia should prevent declaration of death in the field unless obvious lethal injuries are present. Responders at the scene should be reminded that muscle rigidity, skin flushing, and an appearance of death are common features of severe hypothermia.

Self-rescue, exertion, and rough handling are discouraged for hypothermia victims, as these have been associated with cardiac arrest. Because of hypovolemia, transport in a horizontal position is preferred.

Controversy around rewarming in transport can be avoided. On the one hand, aggressive rewarming without extensive warmed volume expansion and patient support is often harmful. On the other hand, most hypothermia victims arrive at the hospital colder than when they left the scene. Rescue and transport are common iatrogenic causes of hypothermia. Thus, although active external rewarming should be avoided, all simple measures should be taken to prevent further cooling. Cold wet clothing must be removed, and dry insulation (blankets or sleeping bag) must be applied. Transport vehicles should be kept as warm as feasible. Warmed IV solutions and warmed airway humidity, if available, do not provide much rewarming but do lessen heat loss. These methods are thus safe and desirable, although they may be difficult except for advanced transport teams. Advanced transport teams should always use core temperature monitoring.

Advanced Life Support

With a focus on rapid, safe, effective rewarming as the mainstay of therapy, much past confusion about alterations in care for hypothermic patients can be avoided. Above approximately 32°C, no major changes in resuscitation are required besides rewarming and volume support. Below 32°C and especially below 28°C, the chief alteration is the suspension of the usual rules regarding declaration of death and the duration of resuscitation.

Closed-chest CPR should be undertaken if the circulation is arrested and with VF or asystole. Life support guidelines suggested a careful search for a pulse before initiation of CPR in severely hypothermic patients. Experts sometimes withheld chest compressions pending circulatory rewarming in cases of proven severe hypothermia (<28°C) when any organized rhythm was present, even in the face of bradycardia, hypotension, or pulseless electrical activity. This was because CPR was felt to be associated with VF in the cold, irritable myocardium; a suspended metabolism requires little circulation; and even high-quality chest compressions are less effective with a stiff thorax and a depleted blood volume. If in any doubt, however, it may be simpler and safer to provide standard CPR to hypothermia victims while establishing effective rewarming.

A key step in circulatory support is the provision of brisk and ongoing heated IV volume support. Peripheral venous access, however, can be difficult in hypothermia. Intraosseous infusion or central line placement, preferably at the femoral vein, may be needed. The volumes required may be large, and central venous pressure monitoring may be helpful, but experts suggest avoiding catheter passage into the cardiac chambers to avoid triggering VF. An indwelling bladder catheter will measure urine output and may quantify the diuresis often seen in these patients. Central venous pressures and especially urinary output may be difficult to interpret, however, given cardiac and renal dysfunction in hypothermia. Basic features of improving perfusion such as pulse quality and blood pressure remain important.

Hypoventilation may be physiologic in severe hypothermia, but airway and breathing support can be provided using standard measures in hypothermia. Endotracheal intubation has not been found to be associated with VF.[33] Intubation is often difficult, however, given rigid jaw and neck muscles. Advanced adjuncts such as video or fiber-optic laryngoscopy may be useful, and supraglottic airways might be considered pending rewarming.

Medications and Defibrillation

No particular medication is indicated for hypothermia itself. Medications and electrical defibrillation were once avoided as ineffective and possibly harmful for cardiac arrest in severe hypothermia, but evidence for this approach was sparse. This topic is discussed thoughtfully in recent guidelines.[1,2] Case reports[4] suggest that vasopressor use and defibrillation at standard energy settings may sometimes be effective. The effectiveness of antiarrhythmics is less clear. At present, it seems reasonable to administer vasopressors and attempt defibrillation as indicated, while also working toward aggressive core or circulatory rewarming. Excessive repetition of medications or electrical shocks is probably unwise, and other medications (eg, insulin) that could persist and be harmful after rewarming should be avoided.

Complications

Among the many potential complications of hypothermia, pulmonary injury, coagulopathy, and renal failure are especially common. These may resolve over some time after rewarming. Neurologic recovery may take even longer. Some patients recover neurologic function rapidly after warming; others may make surprisingly intact recovery only after weeks or months.[5,10] Thus, an early prognosis based on neurologic function is to be avoided.

SUMMARY

The diagnosis of hypothermia is often missed and may be more difficult in colder patients. This deprives some patients of a reasonable chance of intact survival after insults that would otherwise be fatal. The care of accidental hypothermia is complex. A preplanned treatment protocol and team approach can simplify decisions and improve outcomes.

Standard external rewarming methods may be harmful in severe hypothermia and may be ineffective in patients without spontaneous circulation. Active core rewarming methods may be safer and more effective in severe hypothermia, and circulatory rewarming using ECMO or cardiac bypass may be preferred when circulation is absent.

Alterations in resuscitation care for hypothermia are less important than a focus on safe, effective rewarming methods. The limits of intact survival regarding core temperature, anoxic time, CPR time, and other factors have not been established. In patients with hypothermia, it may be simplest and safest to rewarm first and ask questions about outcomes later.

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CME EXAM
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CME EXAMINATION
May 2012

Please mark your answers on the ANSWER SHEET.

Accidental Hypothermia, *Corneli.*

1. Severe hypothermia is defined as a core temperature below approximately
   A. 35°C
   B. 32°C
   C. 28°C
   D. 25°C
   E. 20°C

2. Common causes of accidental hypothermia include
   A. Immersion
   B. Trauma, transport, and resuscitation
   C. Prolonged indoor exposure to cold
   D. Intoxication
   E. All of the above

3. Which stage of hypothermia is most likely present in a shivering patient with blue lips and fingers, agitated mental status, and complaints of feeling cold?
   A. Mild
   B. Moderate
   C. Severe
   D. Profound

4. Which of the following methods would most likely provide rapid rewarming for a patient with no circulation and a core temperature of 27°C?
   A. Forced air rewarming.
   B. Heat lamps plus heat packs applied to axillae and groin.
   C. Intravenous saline and humidified oxygen both heated to 42°C.
   D. Cardiac bypass or ECMO with an extracorporeal warming device.
   E. Left pleural lavage using tap water heated to 40°C.

5. Which of the following is most likely to mean that resuscitation will be ineffective for a patient with asystole in severe hypothermia?
   A. Failure to respond to 30 minutes of aggressive CPR and multiple doses of standard resuscitation medications.
   B. Inability to restore spontaneous circulation after rewarming to 32°C.
   C. Documented submersion for 1 hour.
   D. The patient's core temperature measures below 25°C.
   E. The patient's muscles appear frozen stiff.

ANSWER SHEET FOR THE *PEDIATRIC EMERGENCY CARE* CME PROGRAM EXAM MAY 2012

Please answer the questions on page 481 by filling in the appropriate circles on the answer sheet below. Please mark the one best answer and fill in the circle until the letter is no longer visible. To process your exam, you must also provide the following information:

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Daytime Phone ______________________________

Specialty ______________________________

1. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
2. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
3. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
4. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
5. Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

Your completion of this activity includes evaluating them. Please respond to the following questions below.

Please rate this activity (1 – minimally, 5 – completely)	1	2	3	4	5
Was effective in meeting the educational objectives	○	○	○	○	○
Was appropriately evidence-based	○	○	○	○	○
Was relevant to my practice	○	○	○	○	○

Please rate your ability to achieve the following objective, both before this activity and after it: 1 (minimally) to 5 (completely)

	Pre 1	Pre 2	Pre 3	Pre 4	Pre 5	Post 1	Post 2	Post 3	Post 4	Post 5
1. Classify common causes of hypothermia beyond exposure and immersion.	○	○	○	○	○	○	○	○	○	○
2. Categorize the stages of hypothermia with their approximate temperature thresholds.	○	○	○	○	○	○	○	○	○	○
3. Treat hypothermia using the appropriate methods and indications for active external rewarming, active core rewarming, and circulatory rewarming.	○	○	○	○	○	○	○	○	○	○

How many of your patients are likely to be impacted by what you learned from these activities?

○ <20% ○ 20%–40% ○ 40%–60% ○ 60%–80% ○ >80%

	1	2	3	4	5
Do you expect that these activities will help you improve your skill or judgment within the next 6 months? (1 – definitely will not change, 5 – definitely will change)	○	○	○	○	○

How will you apply what you learned from these activities (mark all that apply):

In diagnosing patients ○ | In making treatment decisions ○
In monitoring patients ○ | As a foundation to learn more ○
In educating students and colleagues ○ | In educating patients and their caregivers ○
As part of a quality or peformance improvement project ○ | To confirm current practice ○
For maintenance of board certification ○ | For maintenance of licensure ○
To consider enrolling patients in clinical trials ○

Other ______________________________

Please list at least one strategy you learned from this activity that you will apply in practice:

	1	2	3	4	5
How committed are you to applying these activities to your practice in the ways you indicated above? (1 – minimally, 5 – completely)	○	○	○	○	○

Did you receive any bias for or againts any commercial products or devices? **Yes** ○ **No** ○

If yes, please explain:

How long did it take you to complete these activities? _______ hours _______ minutes

What are your biggest clinical challenges related to pediatric emergency care?

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CME EXAM ANSWERS
Answers for the Pediatric Emergency Care CME Program Exam

Below you will find the answers to the examination covering the review article in the February 2012 issue. All participants whose examinations were postmarked by May 14, 2012 and who achieved a score of 80% or greater will receive a certificate from Lippincott CME Institute, Inc.

EXAM ANSWER
February 2012

1. B
2. B
3. A
4. C
5. C