Special Situations

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hypothermia; pathophystology; resuscitation; rewarming; treatment algorithm

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Significant hypothermia is an increasing clinical problem that requires a rapid response with properly trained personnel and techniques. Although the clinical presentation may be such that the victim appears dead, aggressive management may allow successful resuscitation in many instances. Initial management should include CPR if the victim is not breathing or is pulseless. Further core heat loss should be prevented by removing wet garments, insulating the victim, and ventilating with warm humidified air/oxygen to help stabilize core temperature. Core temperature and cardiac rhythm should be monitored in the prehospital setting, if possible, and CPR should be continued during transport. In-hospital management should consist of rapid core rewarming in the severely hypothermic victim with heated humidified oxygen, centrally administered warm IV fluids (43°C), and peritoneal dialysis until extra-corporeal rewarming can be accomplished. Postresuscitation complications should be monitored; they include pneumonia, pulmonary edema, cardiac arrhythmias, myoglobinuria, disseminated intravascular thrombosis, and seizures. The decision to terminate resuscitative efforts must be individualized by the physician in charge.

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OVERVIEW OF ISSUES

Severe accidental hypothermia (body temperature below 30°C) is associated with marked depression of cerebral blood flow and oxygen requirement, reduced cardiac output, and decreased arterial pressure. Victims may appear clinically dead because of marked depression of brain and cardiovascular function: full resuscitation with intact neurological recovery is possible, although unusual. {1} Most clinically significant episodes of hypothermia result from an injury in a cold environment, submersion in cold water, or a prolonged exposure to low temperatures without adequate protective clothing. The victims peripheral pulses and respiratory efforts may be difficult to detect, but lifesaving procedures should not be withheld based on clinical presentation.

The very young and the very old are most susceptible to hypothermia. {1-3} In infants, core body temperature will cool more quickly than in adults, as infants have a larger body surface relative to total mass than adults, allowing greater heat loss. Infants also cannot produce as much heat as adults. Older individuals have a lower metabolic rate than the young; thus, it is more difficult for them to maintain normal body temperature when ambient temperatures drop below 18°C. Aging also seems to be accompanied by changes in the ability to detect temperature changes: older people may not seek shelter early enough to avoid becoming hypothermic.

Submersion in cold water can cool the core body temperature much more rapidly than exposure to cold air, because thermal conductivity of water is 32 times greater than that of air. {4} Hypothermia also can occur in relatively warm water conditions if exposure is long enough and if core temperature loss is increased by concurrent ingestion of alcohol.

Alcohol ingestion increases the risk of acquiring or aggravating hypothermia by causing cutaneous vasodilation (which prevents vasoconstriction), impairment of the shivering mechanism, hypothalamic dysfunction, and a decrease in awareness of environmental conditions. {5-7} Other medical conditions that may cause hypothermia include sepsis in the elderly (through central mechanisms), hypothyroidism (through decreased metabolic rate), hypopituitarism, hypoadrenalism, head injury (central mechanisms), drug ingestion (especially barbiturates or phenothiazines through their actions on the central nervous system), and diabetes (especially when hypoglycemia is present).

Clinical Features

As core body temperature declines, the basal metabolic rate and oxygen consumption drop gradually but progressively. {3,4} Mild hypothermia (34 to <36°C) results in shivering, loss of fine motor coordination, lethargy and mild confusion. {3-4-8 } In moderate (30°C to 34°C) to severe hypothermia (below 30°C), the pupils may dilate, and cardiovascular activity ceases (Table). Victims who have experienced near-drowning prior to becoming hypothermic may aspirate water and have pulmonary damage, resulting in a much more difficult postresuscitative course. Since laryngospasm without aspiration of water may accompany near-drowning episodes, hypoxia can occur without significant pulmonary insult from aspirated water.

Thermoregulatory vasoconstriction helps preserve the core temperature by preventing cooling of blood in extremities that subsequently returns to the core. However, with a significant drop in core temperature, the unconscious hypothermic patient may appear clinically dead (without palpable pulse. blood pressure, or respiration) but may still be successfully resuscitated with little or no neurological sequelae if proper and aggressive management is instituted. Fully successful clinical recovery has occurred in a patient with an initial core temperature of 15.2°C caused by accidental hypothermia. in a hypothermic child submerged under water for 66 minutes, and in others with accidental hypothermia. {4-9-10} The use of extra-corporeal bypass can be important in the successful resuscitation of patients suffering from deep accidental hypothermia, especially if near-drowning is not involved.

Hemodynamically, mild hypothermia (34°C to 35°C) causes an increase in pulse rate, peripheral vascular resistance, blood pressure, central venous pressure, and cardiac output. Moderate (30°C to 34°C) and severe hypothermia (below 30°C) can cause bradycardia, arrhythmias (atrial fibrillation is common, but virtually any atrial, junctional, or ventricular arrhythmias can occur), hypotension, and a fall in cardiac output. As the temperature drops below 30°C, the risk of ventricular fibrillation (VF) dramatically increases; as core temperatures drop lower, VF eventually leads to asystole. The J wave (Osbom wave), which is most prominent in lead V3 or V4, occurs in 80% of hypothermic patients and increases in size with decreasing body core temperature. {11} The J wave may also be seen with sepsis and central nervous system lesions. {12}

Oxygenation and acid-base balance also can be altered by hypothermia, with the initial manifestation of mild hypothermia (34°C or higher) being hyperventilation.

Table

Key findings at different degrees of hypothermia

Temperature (C) Clinical Findings

- 37 Normal oral temperature
- 36 Metabolic rate increased
- 35 Maximum shivering seen/impaired judgment
- 33 Severe clouding of consciousness
- 32 Most shivering ceases and pupils dilate
- 31 Blood pressure may no longer be obtainable
- 28~3O
    - Severe slowing of pulse/respiration
    - Increased muscle rigidity
    - Loss of consciousness
    - Ventricular fibrillation
- 27
    - Loss of deep tendon. skin and capillary reflexes
    - Patients appear clinically dead
    - Complete cardiac standstill

As documented by low-registering thermometer.

As the core temperature decreases, there is respiratory depression with subsequent hypoxemia and hypercarbia. {3} A combined respiratory and metabolic acidosis may occur due to hypoventilation, carbon dioxide retention, reduced hepatic metabolism of organic acid due to decreased perfusion of the liver, and increased lactic acid production from impaired perfusion of skeletal muscle and shivering. {3-8} There is some controversy about whether arterial blood gases should be corrected for temperature in the hypothermic patient, although rewarming usually can be expected to correct the metabolic imbalance after the normal circulation is reestablished. {5-3-14} Metabolic acidosis can be seen in hypothermic patients and may not respond to bicarbonate treatment. {15}

Hypothermia affects the function of all organ systems.{4} It can cause the inhibition of release of antidiuretic hormone and decrease oxidative renal tubular activity, causing diuresis and volume depletion. {16} The hematocrit may be elevated due to dehydration and splenic contraction, {4} and plasma viscosity has been found to increase as the core temperature falls below 27°C {4}. Hyperglycemia also may be seen in hypothermic patients due to decreased insulin release and inhibition of peripheral utilization of glucose. This condition often will be reversed with rewarming, although the use of insulin rarely may be necessary in specific cases. {17} Shivering, if prolonged, may cause hypoglycemia, as glycogen stores may become completely depleted. Hypoglycemia also may be an initial laboratory finding in patients who have been exposed to long-lasting physical endurance and exhaustion and often can be noted in alcoholic patients, who already may have depleted glycogen stores. {18}

The mammalian diving reflex may be invoked in pediatric submersion victims. Facial cooling triggers apnea and circulatory shunting to the brain and heart, {15} which may prove protective. This reflex also may occur in adults, although the clinical significance remains unclear. {19}

General Principles of Treatment

Early recognition of hypothermia is essential to maximize survival. Prehospital emergency personnel and emergency department health care providers must maintain a high index of suspicion in any patient with an altered level of consciousness who may have been subjected to even a modestly cool environment. All emergency treatment facilities must have a thermometer capable of registering a temperature of 30°C or less. Emergency health care providers in areas where cold weather emergencies may be expected also must be equipped with and trained to use low-register thermometers (tympanic or rectal probes) and appropriate rewarmmg equipment.

Movement

Because the cold heart is irritable and susceptible to serious arrhythmias (such as VF), all patients with a pulse should be moved gently during transportation or during transfer of the patient from a stretcher to a hospital bed. The patient ideally should have vital signs, core temperature, and cardiac rhythm monitored continuously during transportation, and equipment for resuscitation (including a defibrillator) should be immediately available. Whenever possible, a horizontal position should be maintained during movement in order to minimize any potential orthostatic blood pressure drop due to cold-induced cardiovascular reflex impairment.

Laboratory Tests

When possible, routine laboratory evaluation should be accomplished, including arterial blood gases (ABGs), a complete blood count, prothrombin time, partial thromboplastin time, glucose, electrolytes, blood urea nitrogen, serum creatinine, amylase, liver function tests, ECG, chest radiography; and urinalysis. These tests will allow a baseline to be established and will be most useful in the postresuscitative period when complications can occur. There is general agreement that ABGs need not be corrected during the hypothermic phase, as rewarming will correct all hypothermic-induced alterations. Rewarming remains the primary treatment in severe hypothermia for any abnormalities detected.

Interventions

It is important to stress that the severely hypothermic heart (<30°C) is usually unresponsive to cardioactive drugs, pacemaker stimulation, and defibrillation. {4} Administered medications, including epinephrine. lidocaine, and procainamide, can accumulate to toxic levels if used repeatedly in the severely hypothermic victim. Nonessential interventions should be avoided until the core temperature is increased to above 30°C. However, indicated and necessary procedures (e.g. CPR, ventilation, treatment of significant wounds and injuries) should never be withheld. For example, endotracheal intubation of the severely hypothermic patient may be needed to protect the airway, to correct hypoxemia and hypercarbia, *and to deliver* *warm, humidified oxygen.* Prior ventilation with 100% oxygen may lessen the likelihood of VF when invasive procedures are attempted. During transportation of intubated patients, the tubing of the cuff-port may freeze and break off unless taped firmly to the skin.

Prehospital emergency care providers should be aware that drugs for prehospital use must be prevented from freezing, as this may affect their therapeutic strength after thawing. *Most drugs can be stored safely at 15°C to 30°C, and heated drug boxes may be needed for prehospital resuscitations in which ambient temperatures fall in the low range.*

Passive rewarming methods, to be used in mildly hypothermic victims and as an adjunct in moderate-to-severe hypothermia, include heat packs to arms and groin areas, heating lamps, warmed blankets, and warm-air-heated "sleeping bag" devices.

Active core rewarming techniques are the primary therapeutic modality in hypothermic victims in cardiac arrest or unconscious hypothermic patients with a slow heart rate.

Drugs pertinent for resuscitation also may be needed in reduced dosages, at less frequent intervals, or both. No specific guidelines exist on what reduced dose should be tried, but, in general, the lowest known effective dose can be tried initially if medication is indicated. Likewise, there are no specific recommendations on changing the interval of medication administration, but doubling the usual recommended time between doses would be the initial interval recommended. However, medications, in general, should be avoided in the hypothermic patient in cardiac arrest until the core temperature is above 30°C. Hypoglycemia, if present, can be treated with IV glucose.

Volume depletion is a common clinical finding in the severely hypothermic patient, and IV fluids are indicated. The usual parameters for fluid assessment may be difficult to use in a hypothermic victim, due to large quantities of fluid in the "third space" and the clinical difficulty of obtaining orthostatic blood pressures and weight. It should be emphasized that peripheral access may be quite limited due to vasoconstriction, and a central line may need to be placed upon arrival in the ED. IV infusion sets, urinary catheters, suction tubes, and endotracheal tubes may become stiff and break if not prewarmed prior to prehospital use. *IV solutions also should be prevented from freezing.* but standard formulations of saline and dextrose solutions can be used safely after thawing if no visible precipitates are present and the bags are intact.

IV fluids should be warmed to approximately 43°C prior to administration in the prehospital setting to prevent further core cooling. Methods to warm fluids include using standard blood warmers adapted for saline bag use or portable battery, operated IV line warmers, preheating saline IV bags and storing them in heated carrying packs, and micro waving liter bags of saline with insulation during administration. *The use of an insulation barrier around all IV tubing and solutions can help prevent heat loss from warmed solutions in cold environments.*

Prehospital Management

The dilemma of a normothermic cardiac arrest in a cold environment (e.g. a middle-aged man who has a normothermic cardiac arrest while shoveling snow and subsequently becomes hypothermic) may present a confusing clinical picture. Basic life support and advanced cardiac life support (ACLS) should be instituted as soon as feasible, and the appropriate normothermic ACLS algorithm should be followed. Rewarming techniques may be added to assist in the resuscitative effort. The Figure presents a recommended hypothermia treatment algorithm. *This algorithm presents the recommended actions that providers should take for all possible victims of hypothermia. Once hypothermia is suspected, every effort should be made to prevent further core temperature loss by insulation* and by removing wet garments and to cautiously transport the patient to an appropriate treatment facility.

Increasing body temperature by aggressive external rewarming techniques before CPR is under way will only increase the metabolic demands of the body without any accompanying increase in blood supply, thus increasing the chances of infarction or gangrene. Wet garments should be removed carefully and replaced with dry (preferably warm) garments. {4-20} Blankets and/or an insulated sleeping bag may be used to retain body heat, and efforts should be made to shield the victim from wind chill. Cold sleeping bags should be prewarmed with a volunteer prior to placing a victim inside to prevent core temperature heat loss. Prehospital personnel may lie (stripped to their underwear) alongside a conscious victim underneath the covers to assist in rewarming. *Airway treatments with portable units that can deliver warm, humidified air/oxygen heated to 42-46°C can be used to donate heat back to the core and improve the patient's heat balance. {21} Exercise is not recommended as a rewarming strategy* (unless core temperature is above 35°C) *to prevent fatal arrhythmias secondary to peripheral vasodilation leading to a decline in blood pressure as well as causing cool blood to return to the central circulation. {22}* Afterdrop, a drop in core temperature after resuscitation efforts have begun, may occur through significant heat conduction from the core of the body to more peripheral layers which have not been rewarmed. {23}

ECG monitoring should be performed in the prehospital setting whenever possible during resuscitation and transport. Prehospital personnel also should be aware that adhesive pads for monitor leads will not stick to cold skin, and conduction of electrical signals across cold skin may be impaired in such settings. In patients with moderate-to-severe hypothermia in whom such conduction of ECG signals is affected, needle electrodes may need to be inserted. The needle may be an injection needle punctured through the gel-foam of a conventional adhesive pad which is then. in turn, connected to the ECG electrode of the monitor. This method avoids the need to have specially-made needle electrodes for each machine. In cold environments in which continuous monitoring is desired, tincture of benzoin may be needed to maintain contact of the monitor leads. The QRS amplitude should be maximally amplified if no complexes are seen initially.

Most electrical medical devices to be used in the prehospital setting (defibrillators and monitors) have recommended operating temperatures above 15.5°C, and circuit breakers on generators and power distribution boards should be checked often to prevent freezing. Any required monitoring equipment for prehospital use should be properly insulated prior to utilization. Batteries are affected by very low temperatures, which may affect performance of equipment.

Mild Hypothermia (34°C to 35°C)

Patients with mild hypothermia**(34°C or above)** generally have a good prognosis regardless of the rewarming method used. {4-8} In the conscious patient, external rewarming is appropriate, either passively by using blankets or actively using hot water bottles, warm baths, or chemical heat packs placed under the arms and on the neck, chest, and groin. These methods can allow the patient to warm at a rate of 0.5°C to 1°C per hour. Although quite effective, warm baths have the disadvantage of not allowing the cardiac rhythm to be monitored. Rough movements should be avoided, as discussed above. Wet clothing should be removed carefully, and the patient should be insulated and protected from wind chill. The patient should be cautioned not to exercise as a method of rewarming because of the potential for cardiovascular collapse. Prognosis usually is quite good.

Moderate Hypothermia (30°C to 33.9°C)

Prehospital treatment of moderate hypothermia should include all the basic measures listed above except external rewarming. CPR should be initiated promptly if the patient is in cardiac arrest, although pulse and ventilations may need to be checked for longer periods of time to detect minimal cardiopulmonary efforts. The recommendation that pulse and ventilations be checked for one to two full minutes prior to initiating CPR {24-25} is probably excessive. A maximum of 45 seconds should be adequate time to confirm pulselessness or profound bradycardia for which CPR would be required. *Loss of pupil reflexes, hyporeflexia, absent blood pressure, and lack of response to painful stimuli may not indicate clinical death in the hypothermic patient.* A routine search for external trauma should be accomplished by prehospital personnel, and treatment should be initiated (e.g., pressure dressings, etc.). Obvious physical evidence of death would mitigate against beginning resuscitation (e.g., gross evisceration, decomposition, decapitation). *Stiffness of the victim's body, which can be caused by hypothermia, should not be confused with classic rigor mortis.*

Rewarming is not the mirror image of the cooling process, especially for patients who have developed moderate-to-severe hypothermia over a prolonged period of time. Attempts at rewarming such patients by application of external heat (such as heat lamps, electric blankets, chemical heat packs, etc.) are hazardous, because such interventions will cause sudden peripheral vasodilation and allow cold, lactic acid-rich blood to return to the core and cause a convective afterdrop in core temperature and pH, {21-23} increasing the likelihood of VE. {4}

Minimizing convective afterdrop by preventing return of cool. peripheral blood and by donating heat to the core during initial management is a key goal. This is accomplished by passive rewarming and stabilization methods (covering with blankets, blocking exposure to wind, and removing wet garments). Most afterdrops occur during the first few minutes of treatment, and rewarming efforts in this group of hypothermic victims should be directed to the core (warm humidified oxygen or air; warmed IV fluids).

In the hospital setting, patients who are conscious and have an effective circulation also may be treated with external rewarming to truncal areas only, but constant monitoring must be maintained to detect any potential afterdrop that can occur.

Severe Hypothermia (<30°C)

Although the ability to treat severely hypothermic victims in the prehospital setting will vary depending on the equipment available to prehospital personnel, most resuscitative efforts should be directed to performing CPR in cardiac arrest victims and transporting them to a hospital setting where definitive rewarming can take place. Treatment of severe hypothermia in the out-of-hospital setting remains controversial. *Many providers do not have the equipment or time to adequately assess core body temperature or to institute rewarming with warm, humidified oxygen or warm fluids, although these methods should be initiated if possible to help prevent afterdrop.*

Cardiac monitoring and IV access should be established rapidly if possible. but should not delay transport. *Recently developed portable techniques allow the administration of warm, humidified air or oxygen (heated to 42 - 46°C) and heated lV solutions, {5}* although these are not in widespread use at present. Core temperature determinations in the prehospital setting with either tympanic membrane sensors or rectal probes are recommended, but they also should not delay transfer. Airway management and transportation should be undertaken as gently as possible in order to avoid precipitating VF, and the patient should be moved in the horizontal position to avoid aggravating hypotension through orthostatic mechanisms.

Endotracheal intubation to provide effective ventilation with warm, humidified oxygen and to prevent aspiration should be performed in the unconscious hypothermic patient with inadequate ventilation. In such cases, prior ventilation with 100% oxygen through a bag-valve mask is recommended. In a prospective multicenter study of hypothermia victims, careful endotracheal intubation did not result in a single incident of VF. {26}

If the hypothermic victim is in cardiac arrest, follow the hypothermic treatment algorithm (Figure). If *VF* is detected, emergency personnel should deliver three shocks to determine fibrillation responsiveness (including the use of automated external defibrillators). If VF persists after three shocks, further shocks should be avoided until after rewarming to above 30°C. CPR, rewarming, and rapid transport should immediately follow the initial three defibrillations. If core temperature is below 30°C, successful defibrillation may not be possible until rewarming is accomplished. {4}

Hospital Management

Treatment of severely hypothermic victims in cardiac arrest in the hospital setting should be directed at rapid core rewarming. Additionally, trauma should be sought and treated in hypothermic victims, as injured patients with core temperatures less than 32°C are likelier to die than those with normal temperatures. {27}

Although esophageal temperature is a good indicator of heart temperature, {25} most EDs use tympanic membrane or rectal temperatures. However it should be noted that using tympanic devices in patients with cerumen-blocked external canals or placing rectal probes in frozen feces will not be effective due to the inability to obtain an accurate reading. {5}

Techniques that can be used for rapid core rewarming include the administration of heated, humidified oxygen (42°C to 46°C). warmed (43°C) IV fluids (normal saline) infused centrally at rates of approximately 150 to 200 mL/hr (note: avoid overhydration), peritoneal dialysis with warmed (43°C) potassium-free dialysate administered two liters at a time (no dwell time), and/or extra-corporeal blood warming with partial bypass. {4-5-20-25} A complication of overvigorous hydration is pulmonary edema, which can be treated with standard medications after an effective circulation is restored. Extra-corporeal rewarming should be utilized, if available, in the severely hypothermic patient, as this will allow the most rapid and controlled core rewarming. {9} The use of esophageal rewarming tubes has not been reported in the United States, although they have been utilized extensively in Europe in hospitals without extra-corporeal rewarming equipment. {28} Pleural lavage with warm saline instilled through a chest tube also has been used successfully {26-29} to increase core temperature as much as 2.5°C per hour but has the major disadvantages of possible infection, bleeding, and the requirement for large volumes of fluid. The routine administration of steroids, barbiturates, or antibiotics has not been documented to be of any help in increasing survival or decreasing postresuscitative damage. {30} Additionally; the use of lactated Ringer's solution may be dangerous due to reduced hepatic metabolism of lactate in the hypothermic state. {25}

Bradycardia may be physiologic in severe hypothermia, and cardiac pacing is usually not indicated unless bradycardia persists after rewarming. The temperature at which defibrillation first should be attempted and how often it should be tried in the severely hypothermic patient have not been established firmly. There are also conflicting reports about the efficacy of bretylium tosylate in this setting, {31-32} although it may prove helpful in VF by decreasing the defibrillation threshold.

Recently arterial and venous catheters have been utilized to create a circulatory fistula through which the blood is heated by a modified commercially available countercurrent fluid warmer, thus achieving a more simplified extracorporeal rewarming method. {33} Heparin-free systems are now becoming available {34} which may prevent aggravation of coagulopathies seen in hypothermic patients. Radio frequency rewarming is still being developed as a method of rapid core rewarming. {35}

Continuous core temperature and cardiac monitoring should be performed, as well as placing a urinary catheter to monitor urine output. Pulse oximeters do not work well in vasoconstricted hypothermic patients and will not accurately reflect oxygenation. {5}

Postresuscitative complications may include pneumonia, pulmonary edema. atrial arrhythmias, acute tubular necrosis, acute pancreatitis, compartment syndromes, disseminated intravascular coagulation, hypophosphatemia, hemolysis, intravascular thrombosis, myoglobinuria, seizures, and temporary, adrenal insufficiency. {4-5-36}

Severe accidental hypothermia is a serious and preventable health problem. *Clinicians should look for ''urban" hypothermia in inner city areas, where it has a high association with poverty and drug and alcohol use. {37-38} In rural areas,* *over 90% of hypothermic deaths are associated with elevated blood alcohol levels. {39}*

Terminating Resuscitative Efforts

Some clinicians believe that patients who appear dead after prolonged exposure to cold temperatures should not be considered dead until core temperatures are near normal and CPR still elicits no response. If drowning preceded the victim's hypothermia, successful resuscitation may be unlikely. Hypothermic victims should be treated aggressively, because even when all vital signs are absent, survival without neurological impairment may be possible in certain patients. Although some investigators have suggested elevated potassium as a marker for poor outcome, {40} no specific chemical indicator can predict with complete accuracy who will recover. The old clinical maxim that no one is presumed dead until they have been rewarmed to near normal temperatures can not be applied literally in all cases. Rewarming efforts, in general, probably should be continued until core temperature is at least 32°C and may be discontinued if the patient continues to show no effective cardiac rhythm and remains totally unresponsive to all treatment. However, the decision to terminate resuscitation must be individualized by the physician in charge and should be based on the unique circumstances of each incident.

Successful treatment of hypothermia requires optimal training of emergency personnel and appropriate ACLS resuscitation methods at each institution. Because severe hypothermia is frequently preceded by other disorders (e.g., drug overdose, alcohol use, trauma, etc.), the clinician must seek and treat these underlying conditions while simultaneously treating the hypothermia.

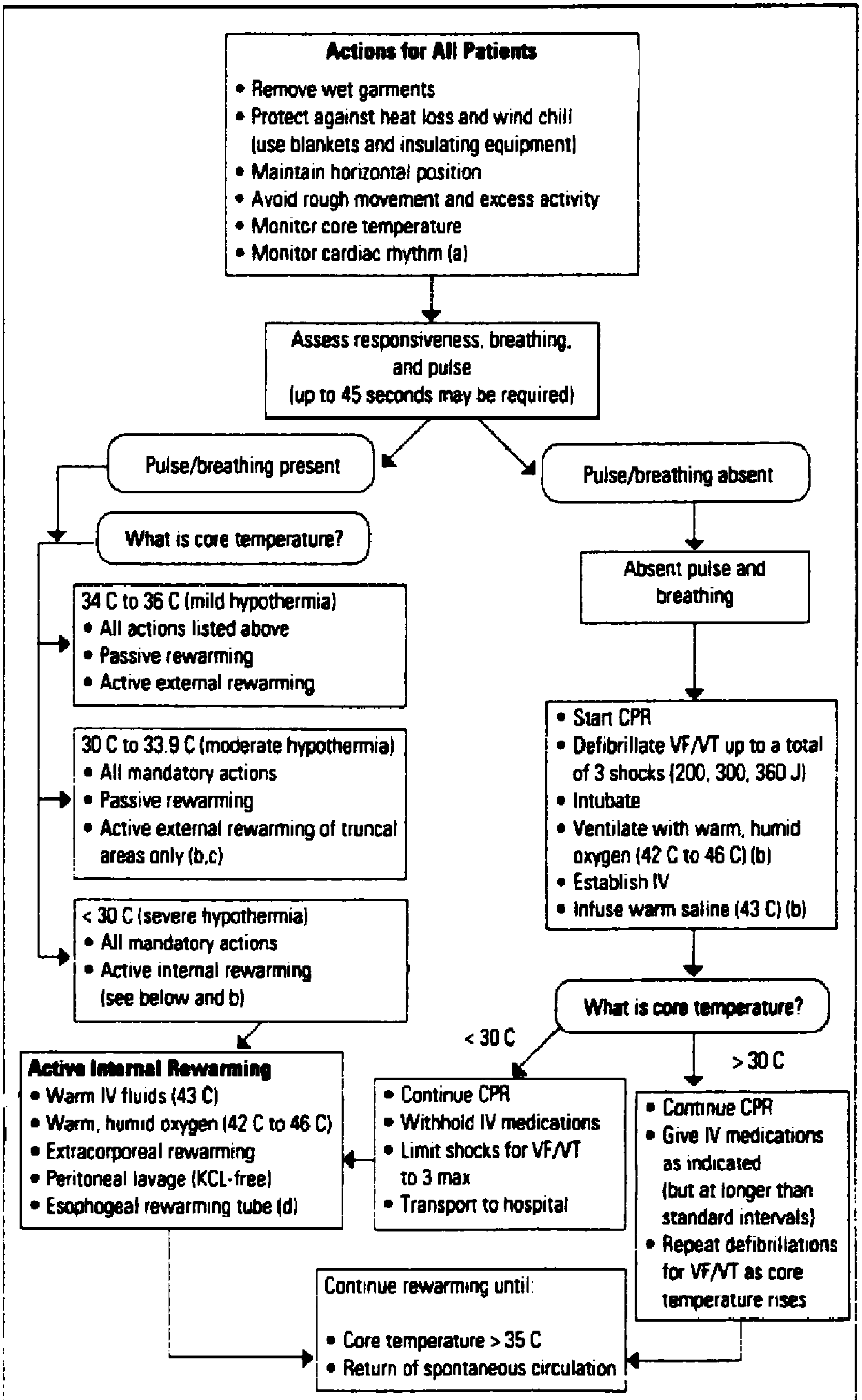
COMMENTARY

The introduction of a new algorithm for the treatment of hypothermia will facilitate the teaching of basic assessment and rewarming techniques to all health care providers. *For hypothermic victims in the prehospital setting, the use of CPR, removing wet clothing and sheltering from wind chill, and stabilization with warmed air/oxygen and IV fluids constitute the initial treatment modalities.* In-hospital rewarming and management can require intubation, central line placement, warmed peritoneal dialysate lavage, and extracorporeal treatment. Close postresuscitative management will require close in-hospital observation for a variety of potential pulmonary, hematologic. and renal complications.

RESEARCH INITIATIVES

Additional research on the use of bretylium and other antiarrhythmic medications in hypothermic VF clearly is indicated, as well as research on dosing and interval reductions required when administering medications in hypothermic victims. Evaluation of the ideal temperature to first attempt defibrillation in patients with hypothermic VF also needs to be conducted. Further research on microwave rewarming of hypothermic patients and other prehospital rewarming techniques needs expansion.

Figure


Actions for All Patients
• Remove wet garments
• Protect against heat loss and wind chill (use blankets and insulating equipment)
• Maintain horizontal position
• Avoid rough movement and excess activity
• Monitor core temperature
• Monitor cardiac rhythm (a)
Assess responsiveness, breathing, and pulse (up to 45 seconds may be required)
Pulse/breathing present
Pulse/breathing absent
What is core temperature?
34 C to 36 C (mild hypothermia)
• All actions listed above
• Passive rewarming
• Active external rewarming
30 C to 33.9 C (moderate hypothermia)
• All mandatory actions
• Passive rewarming
• Active external rewarming of truncal areas only (b,c)
< 30 C (severe hypothermia)
• All mandatory actions
• Active internal rewarming (see below and b)
Absent pulse and breathing
• Start CPR
• Defibrillate VF/VT up to a total of 3 shocks (200, 300, 360 J)
• Intubate
• Ventilate with warm, humid oxygen (42 C to 46 C) (b)
• Establish IV
• Infuse warm saline (43 C) (b)
What is core temperature?
< 30 C
> 30 C
Active Internal Rewarming
• Warm IV fluids (43 C)
• Warm, humid oxygen (42 C to 46 C)
• Extracorporeal rewarming
• Peritoneal lavage (KCL-free)
• Esophogeal rewarming tube (d)
• Continue CPR
• Withhold IV medications
• Limit shocks for VF/VT to 3 max
• Transport to hospital
• Continue CPR
• Give IV medications as indicated (but at longer than standard intervals)
• Repeat defibrillations for VF/VT as core temperature rises
Continue rewarming until:
• Core temperature > 35 C
• Return of spontaneous circulation

(a) May require needle electrodes through the shin.
(b) Many experts think this should be done only in-hospital.
(c) Methods include electric or *charcoal* warming *devices, hot water bottles, heating pads, radiant heat sources, and warming beds.*
(d) Esophageal rewarming tubes are widely used in Europe.

Abbreviations:

VF = ventricular fibrillation
VT = ventricular tachycardia
J= joules
KCL = potassium chloride

REFERENCES:

1. Fox RH. Woodward PM, Exton-Smith AN. et al: Body temperature in the elderly: A national study of physiological, social and environmental conditions. *Br Med J* 1973.1:200-206.

2. Coleman A, Exton-Smith AN. Francis G. et al: A pilot study of low body temperatsres in old people admitted to hospital. J R Coll *Physicians Lond* 1977;11:291-306.

3. Edlich RF. Silloway KA, Feldman PS, et al: Cold inluries and disorders. *current concepts Trauma Care* 1986; .4-11

4. Reuler JB Hypothermia: Pathophysiology, clinical settings and management. *Ann Intern Med* 1978, 89:519-527

5. Schneider SM: Hypothermia. From recognition to rewarming. *Emergency Medicine Reports* 1992;13:l-20

6. Weyrnan AE, Greenbaum DM, Grace WJ. Accidental hypothermia an alcoholic population. *Am J Med* 1974;56: 13-21

7. White JD: Hypothermia: The Bellvue experience. *Ann Emerog Med* 1982;11: 417-424

8. Harnett RM, Pruitt JR, Sias FR. A review of the literature concerning resuscitation from hypothermia I and II *Aviat Space Eviron* Med 1983;54:425-434; 487-495

9. Bolte RG, Black PG, Bowers RS. et al: The uses of extra- coporeal rewarming in a child submerged for 66 minutes. *JAMA* 1998;260:377-379.

10. Walpoth BH, Volken U, Pfaffi T. et al: Accidental deep hypothermia with cardiopulmonary arrest: Extracorporeal blood rewarming in eleven patients. *Eur J cardiothoracic Surgery* 1990;4:390-393.

11. Okada M. Nishimura F. Yoshino H, et al: The J wave in accidental hypothermia. J *Electrocardiol* 1983;16:23-28

12. Danzl DF, Pozos S, Hamlet MP: Accidental hypothermia. in Auerbach RS, Geehr EC (eds): *Management* of *Wilderness and Environmental Emergencies,* ed 2. St Louis. Missouri. Mosby, 1989, p27-63.

13. Wears RL: Blood gases in hypothermia (letter) JACEP 1979;8:247.

14. Ream AK, Reitz BA, Silverberg C: Temperature correction of Pco2 and pH in estimating the acid base status: An example of the emperor's new clothes? *Anesthesiology 1982;56:41-44*

15. Southwick FS, Dalgish PH: Recovery after prolonged asystolic cardiac arrest in profound hypothermia: A case report and literature review. *JAMA* 1980;243:1250-1253.

16. Segar WE: Effect of hypothermia on tubular transport mechanisms. *Am J Physiol* 1956;195:91-96.

17. Samuelson T. Doolittle W, Hawyard J, et al: Hypothermia and cold water near drowning. Treatment guidelines. *Alaska* Med 1982;24:106-111.

18. Haight JS. Keatinge WR: Failure of thermoregulation in the cold during hypoglycemia induced hy exercise and ethanol. J Physiol (Lond) 1973;229:87-97.

19. Bjertnaes L. Hauge A. Kjekshus J. et al: Cardiovascular responses to face immersion and apnea during steady state muscle exercise. A heart catheterization study on humans. *Acta* Physiol Scand 1984;120:605-612.

20. Weinberg AD. Hamlet MP. Paturas JL. et al: C*old Weather Emergencies: Principles of Patient Management.* Branford, Connecticut, American Medical Publishing Co. 1990. p 10-30.

21. Stedha JA: Efficacy and safety of prehospital rewarming techniques to treat accidental hypothermia. *Ann Emerg* Med 1991;20:896-901.

22 Webb P: Afterdrop of body temperature: An alternative explanation. *J. Appl Physiol* 1986;60:385-390.

23. Romett TT: Mechanism of afterdrop after cold water immersion. J *Appl Physiol* 1988. 65:1535-1538.

24. Steinman A. Cardiopulmonary resuscitation and hypothermia. c*irculation* 1986;74:IV 29-32.

25. Zell S, Kurt K: Severe exposure hypothermia: A resuscitation protocol. *Ann Emerg Med* 1985;14:339-345.

26. Hall KN. Syverud SA: Closed thoracic cavity lavage in the treatment of severe hypothermia in human beings *Ann Emerg Med* 1990;19:204-206.

27. Jurkovich GJ: Greiser WB. Luterman A, et al: Hypothermia in trauma victims: An ominous predictor of survival J *Trauma* 1987;27;1019-1024.

28. Kristensen G, Drenck NE, Jordening H: A simple system for rewarming of hypothermic patients. *Lancer* 1986;2:1467-1488.

29. Iversen RJ, Atkin SH. Jaker MA. et al: Successful CPR in a severely hypothermic patient using continuous thoracostomy lavage *Ann Emerg Med* 1990:1335-1337.

30. Moss J: Accidental severe hypothermia *Surg Gynecol Obstet* 1986;162:501-513.

31. Elenbaas RM, Mattson K Cole H, et al: Bretylium in hypothermia-induced ventricular fibrillation in dogs. *Ann Emerg Med 1984;13:994-999.*

32. Buckley JJ, Boncy OK, Bacaner MB: Preventions of ventricular fibrillation is severe accidental hypothermia. *Anesth Analg* 1971;50:587-593.

33. Gentilello LM, Rifley WJ: Continous arteriovenous rewarming. Report of a new technique for treating hypothermia. J *Trauma 1991;31:* 1151-1154.

34. Del Rossi AJ, Cernaianu AC. Vertrees RA, at al: Heparinless extracorporeal bypass for treatment of hypothermia. J *Trauma* 1990;30:79-82.

35. Olsen RG: Reduced temperature afterdrop in rhesus monkeys with radiofrequency rewarming. *Aviat Space Environ Med* 1988;59:78-80

36. Althaus V, Aeberhard P, Schupbach P, et al: Management of profound accidental hypothermia with cardiorespiratory arrest. *Ann Surg* 1982;195:492-495.

37. Woodhouse P, Keating WR, Colshaw SR: Factors associated with hypothermia in patients admitted to a group of inner city hospitals *Lancet* 1989;2:1201-1205.

38.Danzl DF. Pozos RS. Auerbach PS. et al: Multicenter hypothermia *survey. Ann Emerg Med* 1987;74:1159-1160.

39. Gallaher MM. Fleming DW. Berger LR. et al:Pedestrian and hypothermia deaths among native Americans in New Mexico. *JAMA* 1992;267:1345-1348.

40. Schaller MD, Fischer AP, Perret CH: Hyperkalemia: A prognostic factor during acute severe hypothermia *JAMA* 1990;264:1842-1845.

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