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Hypothermia — Recognition and Treatment

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DEFINITION

Hypothermia is defined as a reduction of core body temperature below 35°C, (Normal 37°C). Core temperature is measured with a rectal probe or through the esophagus. Severe and life-threatening hypothermia is when core temperature goes below 30° C. We will discuss here only accidental hypothermia[1] and not intentional hypothermia which is employed in certain surgery or in Intensive Care Unit.

Physiology

The almost unchanging body temperature of warm blooded animals including human beings living under variety of environmental conditions indicates a remarkable efficient thermostatic control and regulatory system. A stable body temperature results from a balance between internal heat production and heat loss to environment (Table 1). The brain process input from peripheral and central thermal sensors regulates body temperature by maintaining this balance. In case core temperature begins to fall, voluntary and involuntary muscle activity such as movement, shivering can increase basal heat production by 2–5 times.[2] Adaptive behavior also plays a role in thermoregulation. Any disease process that affects cognition and motor functions; predisposes patients to hypothermia when this behavior fails to occur.

Classification

1. Primary hypothermia
2. Secondary hypothermia
3. Mixed type includes primary and secondary hypothermia

Primary hypothermia results from failure of heat generation in the face of a cold environment. The difference between ambient and core temperature need not be great. Most heat generation occurs through muscle activity, and as long as the level of muscle activity required to meet the heat loss is maintained, the core temperature too is maintained. The body also defends itself against cold exposure by superficial blood vessels

Table 1:[4] Heat source/exchange and thermoregulatory mechanisms in action

Heat source/exchange	*Impact on core temperature*	*Factors altering effect*
Metabolic heat production	+	Basal metabolic rate falls with core
Radiant and conductive heat exchange	-	Dependent on relative skin and ambient temperatures Vasoconstriction in peripheries reduces skin temperature and hence heat loss
Convective heat exchange	-	Dependent on relative skin and ambient temperatures and on air movement
Evaporative heat exchange	-	Evaporative loss associated with breathing increases as ambient temperature falls

constriction and increased metabolic internal heat production.

Secondary hypothermia results when a disease state interferes with thermoregulation and subsequent failure of any of the multiple pathways that maintain heat balance.

In a nutshell, the body generally loses heat to the environment, and a drop in core temperature is the natural consequence of failed thermoregulation from any cause. Because many disease process interfere with thermoregulation, resulting into hypothermic state, a high index of suspicion is necessary to accurately diagnose and treat secondary hypothermia since many causes are possible and treatment is directed on identification and correction of underlying abnormality.

Prevalence

In US[3], 646 hypothermia-related deaths were reported in 2002 with a death rate of 0.2 per one lac population.

Hypothermia affects all racial groups. However in tropical country like India which has 'hot' climate, the prevalence of hypothermia is far less.

Age

The older persons above the age of 65 are more prone to hypothermia related morbidity and mortality. This is not surprising as elderly patients live in relative poverty and have meager arrangement of heating system, suffer from geriatric problem are candidates for accidental hypothermia.

Sex

Males and females are equally susceptible to excessive cold, among civilian population, most persons who die from Hypothermia are male.

CLINICAL SYMPTOMS (Table 2)

Mild Hypothermia (32° to 35°C)

Early manifestations of mild hypothermia are not specific. There may be weakness, drowsiness, irritability, confusion, impaired co-ordination and shivering. A lowered body temperature may be the sole finding. Skin may appear blue or puffy[4].

The internal (core) body temperature is accidental hypothermia may range from 32° to 35°C. in mild hypothermia, oral temperature is not dependable so oesophageal or rectal probe is essential to record the actual core temperature.

Moderate Hypothermia (28° to 32°C)

Shivering stops, delirium, dilated pupils, reflexes slowed, bradycardia, 'J' curve on ECG

Severe Hypothermia < 28°C or (82.4°F)

Coma, hypotension, very cold skin, metabolic acidosis, ventricular fibrillation and loss of reflexes. Patient may appear dead.

Table 2:[4] Clinical features associated with hypothermia

Core temperature	*Clinical features*
36°C	Increased metabolic rate, vasoconstriction
35°C (hypothermia)	Shivering maximal, impaired judgement
34°C	Uncooperative, dehydrated
33°C	Depressed conscious level
28-32°C	Progressive depression of conscious level, muscle stiffness. Failure of vasoconstrictor response and shivering Bradycardia, hypotension, J waves present on ECG, risk of dysrhythmias (severe hypothermia)
<28°C	Coma, patient may appear dead, absent pupillary and tendon reflexesSpontaneous ventricular fibrillation
20° C	Cardiac standstill

INVESTIGATIONS

Laboratory Studies

- Hypothermia causes a multitude of laboratory abnormalities and could present a confusing clinical picture because the abnormalities may be a result of the hypothermia alone or a reflection of the underlying disease contributing to hypothermia.
- The lab tests that follow should be ordered in all patients. Other testing is dictated by the clinical picture. Tests include the following:
  - ***Blood glucose:*** Hypothermia may cause hyperglycemia. Prolonged hypothermia causes hypoglycemia.
  - ***Serum electrolytes:*** Hypokalemia or hyperkalemia can occur. Electrolytes shift during rewarming occurs and must be monitored closely. High serum potassium levels correlate with a poor prognosis.
  - ***Arterial blod gases:*** The pH rises and PaO_2 and $PaCO_2$ fall as body temperature drops.

    Earlier, mathematically correcting arterial blood gas results were in vogue. Newer literature

suggests that the arterial blood gasses should be interpreted uncorrected for temperature because arterial blood gasses are warmed to body temperature before being processed. Patient result are compared to normal values.

- ***CBC Count:*** Hematocrit increases as plasma volume decreases. The hematocrit level usually increases 2% for each 1ºC drop in core temperature. Associated trauma may cause blood loss; therefore, a normal hematocrit level may be indicative of traumatic blood loss.
- ***Coagulation profile:*** Prolonged bleeding time and clotting time are common. Coagulopathies are common and may be a manifestation of the underlying pathology that has precipitated the hypothermia, such as disseminated intravascular coagulation (DIC) from sepsis.
- The prothrombin time and activated partial thromboplastin time results may appear normal but may not reflect activity in the patient because the blood is warmed in the laboratory in order to perform the test.
- BUN and creatinine usually are elevated secondary to decreased renal blood flow.

– Other tests might be ordered if indicated clinically. Indications may include the following:

- Creatine kinase and amylase may be elevated.
- Liver function tests may give a clue to underlying disorders contributing to or causing hypothermia.
- Cardiac isoenzymes may indicate causative myocardial infarction.
- Fibrin and fibrin split products may indicate DIC.
- Toxicology screen may be indicated.
- Blood alcohol level may need to be checked.

Imaging Studies

- No routine imaging studies are helpful in the evaluation of hypothermia. Studies should be used as an adjunct to therapy in searching for the underlying cause of hypothermia or for coexisting disease.

Other Tests

- Electrocardiogram - J-curve
- PR, QRS, and QTc may be prolonged.
- A classic ECG finding of a J wave, also referred to as an Osborne wave, may be seen.
- A variety of arrhythmias also may be present and may occur as the body is rewarmed. Continuous monitoring is recommended during resuscitation.

Infants

The preterm infant[5] loses more heat due to its larger surface area. The subcutaneous fat is less. Therefore there is diminished fat Insulation. Premature infants cannot augment heat production by increasing muscular Activity. The brown fat which is present in term babies is deficient in preterm Infants. Brown fat occurs in the neck, back groins, axilla and around some viscera. It is mobilised for heat production in response to cold stress. As the preterm Infants is deficient in brown fat. It cannot produce heat in response to cold stress. Thermic responses are also inadequate because of poor food intake, muscular inactivity and less oxygen consumption. Therefore preterm babies are more prone to Hypothermia. Severe hypothermia leads to cold injury. This manifest as redness of face hands and feet while rest of the body appears pale. Hands and feet may become edematous. Neonatal cold injury may be fatal. If it is not recognized early, these babies are managed by slow gentle warming and Infusion of glucose.

Management

Treatment[6-8] begins in the prehospital environment (Fig. 1) with removal of wet clothing passive rewarming of the victim and removal from cold environment. Associated injuries are stabilized and patient should be transported as soon as possible to hospital. Rough handling is avoided which is likely to precipitate cardiac arrhythmia.

Severe hypothermia is a medical emergency and therapy should be instituted at once. The following steps are indicated:

1. An Airway must be established and maintained and the patient should be well oxygenated. Warmed oxygen may be helpful.
2. Blood gases should be monitored, they should be corrected for temperature.
3. Fluid Therapy - Blood volume should be expanded with glucose and saline, low molecular weight, dextran , or Albumin. Maintenance of blood volume is necessary to prevent. Infarction which have been a hall mark in fatal cases can averted by rewarming.
4. Restoration of pH and electrolyte imbalance, sodium bicarbonate should be given if pH is less than 7.25. Both hypo and hyperkalemia may occur in hypothermia and also because of tendency of arrythmias.

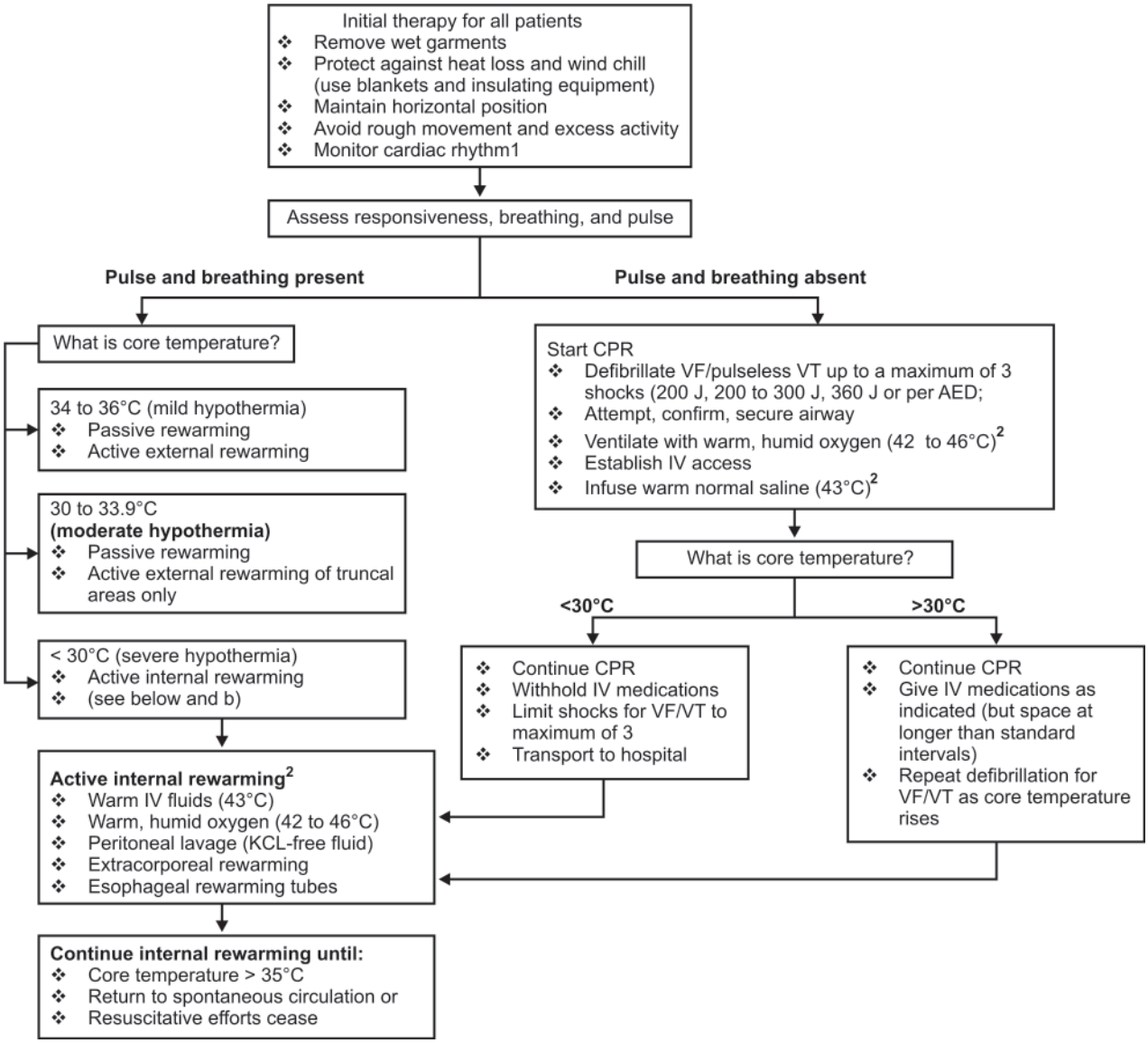

Fig. 1: Hypothermia treatment algorithm[14]

Serum potassium concentrations should be monitored carefully. A transvenous pacemaker may be indicated.

5. *Rewarming:* External rewarming[13] with blankets in a warm room is appropriate in patients with mild hypothermia. Patients who are moderately hypothermic require reestablishment of core temperature. This can be done effectively by placing the patient in a warm bath or a hubbard tank at 104° to 108°F (40–42°C). When there is severe hypothermia exists, active rewarming should be done either with alcohol, circulating blankets or (in extreme cases) by peritoneal dialysis. Dialysis fluid is kept at 37–40°C or by partial cardiopulmonary bypass is the last resort. However these measures are not universally available. It is particularly important to rewarm the myocardium because in cases of VF, Defibrillation will not be successful untill myocardial temperature is raised to near-normal levels.

6. *Other complications:* Tendency for these patients to develop Pneumonia[8-12], which should be treated promptly with Antibiotics, Corticosteroids are also useful and can be given as Hydrocortisone IV every 4-6 hours for first 24 hours.

Resuscitative efforts should be vigorous and prolonged despite the poor prognosis which is related primarily to the advanced age and associated deblitating disease of these patients. In younger individuals some remarkable rescues have been recorded, one young woman was resuscitated even after her temperature had dropped to 69ºF (20.6ºC).

Authorities agree that hypothermia victims without vital sign's (prolonged asystole) should not be pronounced dead untill they have been rewarmed to 96.8ºF (36ºC) and remain unresponsive to CPR at that temperature.

SUMMARY

The almost constant body temperature in human being, living under variety of environmental conditions indicate a remarkable thermostatic control and regulatory systems. In summary, the body generally loses heat to the environment and a drop in core temperature is the natural consequences of failed thermoregulation for any reason. Because many disease processes can and do affect thermoregulation, resulting into hypothermic states. The prompt diagnosis and timely treatment is most rewarding.

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