

Hypothermia

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1. Core Definition

Hypothermia is a profound and dangerous medical condition characterized by a significant reduction in the body's core temperature, typically defined as below 35°C (95°F). This critical drop occurs when the body loses heat faster than it can produce it, leading to a cascade of physiological impairments. Initially, the body attempts to compensate for heat loss through various thermoregulatory mechanisms, such as peripheral vasoconstriction to conserve heat and shivering to generate heat. However, prolonged exposure to cold environments, including frigid air, snow, or cold water, eventually overwhelms these compensatory mechanisms, causing the core temperature to plummet further.

The severity of hypothermia is directly correlated with the extent of the core temperature drop, influencing the prognosis and the urgency of intervention. As the body temperature falls, vital organ systems, including the cardiovascular, respiratory, and neurological systems, begin to malfunction. Cellular metabolic processes slow down, and enzyme functions become impaired, leading to a progressive deterioration of bodily functions. Without timely and appropriate intervention, severe hypothermia can culminate in cardiac arrest, neurological damage, and ultimately, death, as the body's ability to sustain life is irrevocably compromised.

This condition is not merely a sensation of being cold but a systemic physiological crisis. The initial response to cold, such as shunting blood flow away from the limbs to concentrate it in the vital organs, can be considered a temporary life-saving measure. This centralizes warmer blood around the heart, lungs, and brain, protecting them from immediate temperature drops. However, this protective mechanism is finite; if the core temperature continues to fall, even these vital organs will eventually succumb to the cold, losing their ability to function effectively and initiating a fatal sequence of events throughout the body.

2. Classification and Stages

Hypothermia is typically classified into several stages based on the patient's core body temperature, which guides clinical management and prognostication. The most widely accepted classifications divide hypothermia into mild, moderate, and severe categories. **Mild hypothermia** is generally defined as a core temperature between 32°C (89.6°F) and 35°C (95°F). At this stage, the body's compensatory mechanisms are still active, resulting in symptoms such as intense shivering, vasoconstriction, increased heart rate, and mild confusion. The individual may still be able to maintain some level of self-care and communication, though judgment may be impaired.

As the core temperature drops further, the condition progresses to **moderate hypothermia**, typically ranging from 28°C (82.4°F) to 32°C (89.6°F). In this stage, shivering often ceases or becomes intermittent, paradoxical undressing may occur, and consciousness deteriorates, leading to lethargy, profound confusion, and eventually stupor. Heart rate and respiratory rate decrease significantly, and cardiac arrhythmias, particularly atrial fibrillation, become more common. Muscle rigidity increases, and pupils may become dilated and sluggish, presenting a challenge for differential diagnosis with other conditions. The body's ability to generate heat is severely compromised, and active rewarming becomes crucial.

Severe hypothermia is diagnosed when the core body temperature falls below 28°C (82.4°F). This stage is life-threatening, characterized by a significant depression of all vital signs. The patient may appear comatose, unresponsive, and clinically dead, with profound bradycardia (extremely slow heart rate) or asystole (absence of heart activity). Respiration becomes very shallow or undetectable, and reflexes are absent. Ventricular fibrillation, a chaotic and often fatal heart rhythm, is a significant risk. At temperatures below 20°C (68°F), the brain's electrical activity may cease, a state sometimes referred to as profound hypothermia, demanding highly specialized and aggressive resuscitation efforts.

3. Etymology and Historical Development

The term "hypothermia" is derived from Greek roots: "hypo," meaning "under" or "below," and "therme," meaning "heat." This etymology accurately reflects the core definition of the condition as a state of subnormal body temperature. Although the medical term itself is relatively modern, the phenomenon of individuals succumbing to cold has been recognized since antiquity. Early human societies, living in diverse climates, undoubtedly encountered and understood the dangers of severe cold exposure, often linking it to death and illness, even if they lacked a scientific understanding of core body temperature regulation.

Historical records and military accounts frequently describe casualties from cold exposure, particularly during expeditions or prolonged sieges in harsh winter conditions. For instance, the Napoleonic Wars, especially the retreat from Moscow in 1812, are replete with accounts of soldiers dying from freezing temperatures, illustrating the devastating impact of hypothermia on large populations. However, the scientific study of hypothermia, its physiological effects, and potential treatments began to formalize much later, gaining momentum in the 19th and 20th centuries. Pioneering physiologists started to investigate the body's thermal regulation and the systemic responses to cold stress.

Significant advancements in understanding and treating hypothermia occurred during the mid-20th century, particularly driven by observations from military conflicts and mountaineering accidents. Research into the mechanisms of heat loss, the effects of cold on cardiovascular and neurological

function, and effective rewarming strategies progressed. The development of modern emergency medicine and critical care further refined protocols for managing hypothermic patients, leading to improved outcomes. Today, the understanding of hypothermia encompasses not only environmental exposure but also its controlled induction in medical settings, such as therapeutic hypothermia, to protect organs during certain medical procedures or after cardiac arrest.

4. Pathophysiology

The pathophysiology of hypothermia is a complex interplay of the body's thermoregulatory responses being overwhelmed by sustained heat loss. Under normal conditions, the human body maintains a stable core temperature (homeostasis) through a delicate balance of heat production (metabolism, muscle activity) and heat loss (radiation, convection, conduction, evaporation). When exposed to cold, the hypothalamus, the body's thermoregulatory center, initiates a series of responses. Initially, **vasoconstriction** of peripheral blood vessels occurs, reducing blood flow to the skin and extremities to minimize heat loss to the environment. This shunting of blood centrally helps to preserve core temperature, protecting vital organs.

Following vasoconstriction, the body activates mechanisms to increase heat production. The most prominent of these is **shivering**, an involuntary rhythmic muscle contraction that can significantly increase metabolic heat generation. Non-shivering thermogenesis, primarily through the metabolism of brown adipose tissue (more prominent in infants), also contributes. However, these mechanisms are energy-intensive and finite. Prolonged shivering depletes glycogen stores, leading to fatigue and eventually the cessation of shivering, which marks a critical point in the progression of hypothermia, as the body loses its primary active heat-generating capacity.

As core temperature continues to drop, the systemic effects become profound. The cardiovascular system is particularly vulnerable; heart rate and cardiac output decrease, blood pressure drops, and myocardial contractility diminishes. The heart becomes increasingly irritable and prone to arrhythmias, with ventricular fibrillation being a common cause of death in moderate to severe hypothermia. The central nervous system experiences a progressive depression, leading to impaired judgment, confusion, lethargy, stupor, and eventually coma. Respiratory rate and tidal volume decrease, leading to hypoventilation and potential acidosis. Renal function is also affected, initially with a cold diuresis (increased urine output) due to peripheral vasoconstriction and then progressing to renal impairment as circulation deteriorates. Coagulation abnormalities and metabolic disturbances, such as hyperglycemia followed by hypoglycemia, are also common, contributing to the systemic compromise.

5. Key Characteristics and Symptoms

The presentation of hypothermia varies significantly depending on its severity, but a common

thread is the progressive decline in neurological, cardiovascular, and metabolic functions. In **mild hypothermia** (32-35°C), individuals typically exhibit vigorous shivering, which is the body's primary immediate response to generate heat. They may complain of feeling cold, experience numbness in extremities, and show signs of mild confusion, lethargy, or poor coordination. Their speech might be slurred, and their movements clumsy, indicating early central nervous system compromise. The skin often appears pale and cool to the touch, especially in exposed areas, due to peripheral vasoconstriction.

As hypothermia progresses to the **moderate stage** (28-32°C), shivering often diminishes or ceases entirely, which is a critical warning sign as it indicates the body's compensatory mechanisms are failing. Mental status deteriorates further, leading to increased confusion, disorientation, amnesia, and a decreased level of consciousness, sometimes progressing to stupor. Paradoxical undressing, where individuals remove clothing due to a false sensation of warmth, may occur. Muscle rigidity becomes more pronounced, and reflexes are sluggish. Heart rate and breathing slow down noticeably, and the pulse may be weak or irregular. The risk of serious cardiac arrhythmias, particularly ventricular fibrillation, increases significantly at this stage, making careful handling of the patient crucial to avoid precipitating such events.

In **severe hypothermia** (below 28°C), the patient appears critically ill or even clinically dead. Shivering is absent, and the individual is typically unconscious and unresponsive, with fixed and dilated pupils, a sign that can be mistaken for brain death. Breathing may be extremely shallow, irregular, or undetectable, and the heart rate can be profoundly slow (bradycardia) or absent. The skin is cold to the touch, and muscles are stiff. The body becomes extremely rigid, often described as "cold and stiff," resembling rigor mortis. Despite these dire signs, individuals in severe hypothermia, especially children, have been known to survive prolonged periods, leading to the adage: "No one is dead until warm and dead." This underscores the importance of continued resuscitation efforts until rewarming has been achieved.

6. Causes and Risk Factors

The primary cause of hypothermia is an imbalance between heat production and heat loss, predominantly due to exposure to cold environments. However, the etiology is often multifactorial, involving a complex interaction of environmental, physiological, and behavioral factors. Prolonged immersion in cold water or exposure to cold air without adequate protective clothing are classic environmental causes. Even seemingly moderate temperatures can lead to hypothermia if the exposure is extended, especially when combined with wind, wetness, or exhaustion. Wind chill significantly accelerates heat loss through convection, while wet clothing loses its insulating properties, promoting heat loss through conduction and evaporation.

Beyond environmental exposure, numerous other factors can predispose an individual to

hypothermia by impairing the body's ability to regulate temperature or perceive cold. **Age** is a significant risk factor; infants and elderly individuals are particularly vulnerable. Infants have a larger surface area-to-volume ratio, less subcutaneous fat, and an immature thermoregulatory system, while the elderly may have reduced metabolic rates, impaired shivering responses, diminished perception of cold, and less mobility. **Medical conditions** such as hypothyroidism, hypoglycemia, sepsis, severe trauma, stroke, Parkinson's disease, and spinal cord injuries can all compromise thermoregulation or lead to immobility, increasing the risk.

Substance use is another major contributing factor. Alcohol causes peripheral vasodilation, leading to increased heat loss, while simultaneously impairing judgment and awareness of cold. Illicit drugs can also alter consciousness and thermoregulation. **Medications**, including certain sedatives, antidepressants, and antipsychotics, can interfere with the body's ability to maintain core temperature. Furthermore, **malnutrition** and dehydration reduce the body's energy reserves needed for heat production. Homeless individuals, those with mental illness, and people engaged in outdoor occupations or recreational activities without proper preparation are also at elevated risk due to a combination of environmental exposure, inadequate resources, and behavioral vulnerabilities.

7. Clinical Management and Treatment

The clinical management of hypothermia focuses on preventing further heat loss, initiating rewarming, and providing supportive care to mitigate the physiological complications. Initial steps involve removing the patient from the cold environment, removing any wet clothing, and insulating them with dry blankets or sleeping bags to prevent further heat loss. Gentle handling is paramount, especially in moderate to severe hypothermia, as sudden movements can trigger life-threatening cardiac arrhythmias, such as ventricular fibrillation, in the cold, irritable heart.

Rewarming strategies are categorized into passive external rewarming, active external rewarming, and active internal (core) rewarming. **Passive external rewarming** is suitable for mild hypothermia and involves allowing the patient's own metabolic heat production to rewarm them, primarily by providing insulation. This includes warm, dry blankets, and warm, non-alcoholic, non-caffeinated fluids if the patient is conscious and able to swallow. **Active external rewarming** is employed for moderate hypothermia and involves applying external heat sources such as forced-air warmers ("Bair Huggers"), heating pads, warm water immersion (if practical and safe), or radiant heat. These methods directly transfer heat to the skin and superficial tissues, which then warms the core.

For severe hypothermia (below 28°C), **active internal (core) rewarming** techniques are often necessary due to the severe depression of metabolic function and the critical state of the patient. These methods directly warm the core organs and blood, offering the most rapid and effective

rewarming. Techniques include warmed intravenous fluids, warm humidified oxygen via intubation, gastric or bladder lavage with warm fluids, peritoneal lavage, and, in the most severe cases, extracorporeal membrane oxygenation (ECMO) or cardiopulmonary bypass. These advanced techniques circulate the patient's blood through an external device that warms it before returning it to the body, providing simultaneous rewarming and circulatory/respiratory support. Throughout all stages, continuous monitoring of core temperature, cardiac rhythm, and vital signs is essential, and aggressive resuscitation for cardiac arrest in hypothermic patients should continue until the patient is rewarmed to at least 32°C (89.6°F), or higher, before cessation of efforts.

8. Prevention and Prognosis

Prevention of hypothermia revolves around adequate preparation for cold environments, appropriate clothing, and awareness of risk factors. Dressing in layers allows for flexibility in adjusting insulation to changing activity levels and environmental conditions; the innermost layer should wick moisture away from the skin, while outer layers provide insulation and protection from wind and wetness. Avoiding prolonged exposure to cold, especially when wet, fatigued, or under the influence of alcohol, is crucial. Maintaining adequate hydration and nutrition, particularly when active in cold weather, helps sustain the body's metabolic heat production. Recognizing the early signs of hypothermia in oneself and others can facilitate timely intervention before the condition becomes severe.

The prognosis for hypothermia varies widely depending on the severity of the core temperature drop, the duration of exposure, the patient's overall health status, and the promptness and effectiveness of rewarming efforts. In mild cases, full recovery is common with appropriate rewarming. However, as the hypothermia deepens, the risk of morbidity and mortality increases significantly. Complications can include cardiac arrhythmias, acute respiratory distress syndrome (ARDS), renal failure, pancreatitis, disseminated intravascular coagulation (DIC), and frostbite if local tissue freezing has occurred. Neurological sequelae, ranging from cognitive deficits to persistent vegetative states, can result from prolonged cerebral hypoxia, especially if cardiac arrest occurred.

Despite the grim presentation of severe hypothermia, particularly when associated with cardiac arrest, the prognosis is not always hopeless. The "protective" effect of cold, which reduces metabolic demand in tissues, especially the brain, can sometimes allow for remarkable recoveries, even after prolonged periods without detectable vital signs. This is especially true in cases of accidental hypothermia, such as cold water immersion, where rapid cooling might protect the brain from ischemic damage. Therefore, aggressive and sustained resuscitation efforts are often warranted for severely hypothermic patients, continuing until the patient has been fully rewarmed and is confirmed to be unresponsive to all medical interventions.

9. Significance and Impact

Hypothermia represents a significant public health concern globally, affecting diverse populations from outdoor enthusiasts to vulnerable urban residents. Its impact spans various fields, from emergency medicine and critical care to public health policy and climate change studies. Annually, thousands of individuals worldwide are treated for hypothermia, with a substantial number of fatalities, particularly among the homeless, elderly, and those exposed to extreme weather events. The economic burden includes direct medical costs, long-term care for survivors with complications, and lost productivity.

In clinical practice, understanding hypothermia is critical for emergency responders, wilderness rescue teams, and hospital staff. The condition demands rapid recognition and appropriate management, often in challenging environments. Beyond accidental exposure, the deliberate induction of mild hypothermia, known as **therapeutic hypothermia** or targeted temperature management, has become a standard practice in specific medical contexts. This controlled cooling is used to improve neurological outcomes after cardiac arrest, during neurosurgery, and in certain other critical care scenarios, demonstrating the dual nature of cold's effect on the human body--potentially fatal in uncontrolled scenarios, yet therapeutically beneficial when carefully managed.

The broader societal impact of hypothermia is evident in public safety campaigns, architectural design in cold climates, and disaster preparedness. Education on appropriate clothing, shelter, and recognition of symptoms is vital for preventing cold-related injuries and deaths. Climate change, with its potential for more extreme weather events, including intense cold snaps, may further elevate the risk of hypothermia in unprepared populations. Therefore, a comprehensive understanding of hypothermia's pathophysiology, risk factors, and management strategies remains an indispensable part of medical knowledge and public health initiatives.

10. Debates and Special Considerations

While the core definition and management principles of hypothermia are well-established, certain aspects continue to be subjects of debate and require special consideration. One intriguing area involves the remarkable survival rates of young children following severe hypothermia, particularly after cold water immersion. Documented cases exist where children have survived lengthy stays in cold water, or with core body temperatures dropping as far as 55.4°F (13°C), often with minimal neurological deficits. This phenomenon is often attributed to several factors: the diving reflex (which shunts blood to vital organs and slows metabolism), a larger relative brain size, and potentially a higher metabolic reserve or different physiological response to cold compared to adults. However, the precise mechanisms and predictive factors for such extraordinary recoveries are still subjects of ongoing research and clinical observation.

Another critical area of debate centers on the criteria for cessation of resuscitation efforts in

profoundly hypothermic patients who present in cardiac arrest. The traditional medical maxim, "No one is dead until warm and dead," reflects the potential for recovery even after prolonged periods of apparent circulatory arrest. This principle advocates for continued resuscitation, sometimes for several hours, while actively rewarming the patient, especially if the hypothermia was accidental and the patient's underlying health was otherwise good. However, practical and ethical challenges arise regarding resource allocation, the potential for neurological damage despite rewarming, and the determination of futility, leading to ongoing discussions in emergency medicine and critical care communities about optimal protocols and decision-making frameworks.

Furthermore, the management of complications such as severe cardiac arrhythmias in hypothermic patients requires careful consideration. The cold heart is often refractory to standard antiarrhythmic medications and defibrillation until a certain degree of rewarming has occurred. This necessitates a cautious approach to pharmacological interventions and electrical therapies, emphasizing gentle handling and prioritizing rewarming. The unique challenges posed by hypothermia, from its subtle initial signs to its life-threatening advanced stages, continue to inform medical training, research, and the development of specialized care protocols for this critical condition.

Further Reading

[Hypothermia - Wikipedia](#)

[Hypothermia - Mayo Clinic](#)

[Hypothermia - Centers for Disease Control and Prevention \(CDC\)](#)

[Hypothermia - StatPearls \(National Center for Biotechnology Information\)](#)

[2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care: Part 10: Special Circumstances of Resuscitation - Circulation](#)