# SCIENTIFIC SECTION

# Review Article

## Diagnosing and treating hypothermia

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**Mild or moderate hypothermia may be underdiagnosed in Canada. This paper presents five cases of treated hypothermia, describes the pathophysiologic aspects of cold injuries and discusses the rationale and techniques of rewarming. An orderly series of specific clinical and laboratory observations is proposed to ensure prompt and accurate diagnosis and treatment, and to improve the management of hypothermia.**

**Il est possible que l'hypothermie peu sévère ou modérée soit sous-diagnostiquée au Canada. Cette publication présente cinq cas d'hypothermie et leur traitement, décrit les aspects physiopathologiques des lésions causées par le froid et de l'hypothermie, et discute les principes des techniques de réchauffement. On propose une liste méthodique d'observations cliniques et de résultats de laboratoire spécifiques permettant d'en assurer un diagnostic rapide et précis ainsi qu'un meilleur traitement.**

Hypothermia is said to exist when a patient's core temperature has dropped to 35°C or less as measured by a rectal, esophageal or tympanic monitor. In a country such as Canada, where the atmospheric temperature may be low for at least half the year, the staff of community hospitals can expect to receive patients suffering from accidental hypothermia because of exposure to cold outdoors. Elderly persons and those with problems requiring medical or surgical care are threatened by a more subtle form of hypothermia that may mimic a variety of conditions.[1-7] Oral temperatures are a reliable index of core temperatures and can be used with confidence to exclude a diagnosis of hypothermia. In a clinical situation in which a low oral reading suggests a problem, the core temperature should be measured rectally to verify the presence and categorize the level of hypothermia.[1,2]

The diagnosis of hypothermia may be delayed in a community hospital. When the condition has been recognized, its management may be hampered because those in attendance are unfamiliar with the physiologic features and possible complications of cold injury and do not have an established protocol to follow for its treatment.

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### Case reports

The following cases were taken from the files of the two community hospitals in Peterborough, Ont. during a 3-year period.

*Case 1*

On a January day with an ambient temperature of −20°C a 13-year-old girl was buried under debris when her house exploded and burned. After having been soaked by fire hoses she waited for 2 hours before being uncovered and taken to hospital. Her rectal temperature was well below 33°C, the lowest estimated reading on the clinical thermometer used. Her pulse exceeded 180 beats/min and her systolic

**On the cover of this issue of the Journal is a detail from "H.M.S. Phoenix and the Breadalbane at the moment when the latter was crushed and sunk", an 1854 chromolithograph by E.A. Inglefield that depicts a potentially hypothermic situation. In his caption the artist explains: "The field of ice easing off from the Phoenix passed astern to the Breadalbane and entering her bow she filled and sank in less than 15 minutes in 30 fathoms of water." He then dedicated his work to the captain and crew of the Breadalbane, assuming, no doubt, that this supply ship of the Royal Navy, which sank in 1853 in Lancaster Sound at the north end of Baffin Island, would never be seen again. In September 1981 the Breadalbane was not only seen but also photographed by a team of scientists and divers led by Joseph MacInnes, a physician and underwater explorer from Toronto. MacInnes, who discovered the Breadalbane last year after a 3-year search, is planning an extensive investigation of the wreck next April. (From transparency C-227, loaned courtesy of the picture division, Public Archives Canada, Ottawa.)**



←For prescribing information see page 1143

blood pressure was below 90 mm Hg. Monitoring was difficult because of her violent shivering. After 2 or 3 hours of active rewarming with hot blankets and hot fluids given orally her rectal temperature rose above 35°C. When her temperature was normal she stopped shivering and her blood pressure and heart rate returned to normal. She was discharged after 3 days.

*Case 2*

An 18-year-old boy was knocked from his motorcycle and lay with a fractured femur in summer rain on the road for an hour or more before being taken by ambulance to hospital. He had tachycardia and hypotension. As well, because his persistent shivering interfered with monitoring, his rectal temperature was taken and found to be below 34°C, the lowest estimated reading on the clinical thermometer used. Through the application of hot water bottles and heating blankets his rectal temperature was raised above 35.2°C in an hour. His clinical shock was resolved by intravenous solutions that had already been administered.

*Case 3*

In June a 70-year-old man with chronic alcoholism was taken to hospital because of gastrointestinal bleeding. He had been living alone in a poor-quality rooming house and had been eating irregularly for 6 months. On the evening of his admission he had vomited blood in the communal bathroom and had been found lying unconscious on the cold tile floor. When the usual resuscitative measures of giving blood and fluids intravenously and performing gastric suction did not relieve his nausea and vomiting or correct his hypotension, tachycardia and frequent extrasystoles, his rectal temperature was measured and found to be below 33°C. Active rewarming with hot blankets and hot water bottles was started. When the patient's body temperature had been raised to normal his vomiting stopped and his cardiovascular condition stabilized. His hemoglobin concentration, which had been 5 g/dl at the time of admission, was 14 g/dl by the next morning, although he had been given only 6 units of blood.

*Case 4*

Late in September a 3-year-old boy fell into a river and was rescued after being immersed for about 15 minutes. An ambulance arrived about 15 minutes later, and within 13 minutes the child was admitted to an emergency department. During transit his lungs were suctioned, cardiac massage was started and ventilation with oxygen and an Ambubag was performed. On arrival at the hospital he was asystolic and was not breathing spontaneously. His core temperature, taken with a rectal probe, was below 27°C, the lowest temperature that could be recorded on the Accra-Temp thermometer (Gaymar Industries, Orchard Park, New York) used. He was given bicarbonate and isoproterenol (Isuprel), and the cardiac massage and mechanical ventilation were continued. Within 30 minutes his rectal temperature was 28.2°C, his heart had a junctional rhythm of 50 beats/min and he began to breathe shallowly at a rate of 15 respirations/min. When the systolic blood pressure in his brachial artery rose to 90 mm Hg cyanosis and pulmonary edema developed. Hydrocortisone (Solu-cortef), dexamethasone (Decadron) and furosemide (Lasix) were given. An initial test of the arterial blood gases showed a pH of 6.83, a partial pressure of oxygen of 180 mm Hg and a partial pressure of carbon dioxide of 36 mm Hg; after 75 minutes of resuscitative measures the corresponding values were 7.52, 36 mm Hg and 21 mm Hg. Fortuitously, an air ambulance had been summoned on the day of this accident for a sick child at the other community hospital. It was able to accommodate this boy and he was transferred immediately to the Hospital for Sick Children in Toronto. There the child was managed by controlled hypothermia with cerebral pressure monitoring for a further 96 hours and then allowed to awaken; at that time he showed no apparent neurologic abnormality.[8] Several years later the boy is living a relatively normal life. He apparently does well in school and is learning to play hockey, although his mother says his right arm "tires easily".

*Case 5*

A 17-year-old boy had taken diazepam (Vivol), dimenhydrinate (Gravol) and alcohol at a party and fallen asleep on the front lawn of his house. He slept for 8 hours during a night in which the temperature was below −20°C. On arrival at hospital he was comatose and areflexic, and his muscles were rigid. However, his cardiac and respiration functions were almost normal. His initial core temperature was probably in the low 20s because it was only 27°C, the lowest reading on the Accra-Temp probe, after 1 hour of intensive treatment. He was treated with hot humid air inspired spontaneously, bladder and gastric irrigation with water at 40°C, intravenous infusions of warmed solutions and the application of hot water bottles, heated to 42°C, to the lateral chest wall, neck and groin. His muscle rigidity disappeared at a body temperature of 31°C. He awoke when his rectal temperature reached 32°C. Over the next 3 to 4 hours he was allowed to rewarm spontaneously to 37°C. Within 48 hours he was moving around in the intensive care unit, showing no measurable physiologic problems. During the early phase of his warming he was also given dextran 40 (Rheomacrodex), mannitol (Osmitrol), dexamethasone (Decadron), bicarbonate and prophylactic antibiotics.

## Pathophysiologic features of hypothermia[9-13]

Cold injury to any body cell is attributed to one or a combination of the following mechanisms:

● The metabolism of each cell and its membrane is slowed by the fall in temperature; eventually the cell dies.

● With cooling the cell gradually dehydrates so that enzymes and electrolytes are concentrated to toxic levels. When extracellular water freezes it crystallizes and compresses the cell mass, further concentrating the enzymes and electrolytes. Eventually the intracellular water freezes, damaging and disrupting the cell.

● After initial vasodilation there is progressive vasospasm that is mediated by the hypothalamus in an attempt to retain heat. Finally edema, ischemia and, ultimately, intravascular clotting occur. In addition, as the temperature drops, the rate of dissociation of oxyhemoglobin declines, reaching zero when the body cools to 10°C. In some cigarette smokers a 10% carboxyhemoglobin level is the baseline value. Thus, they face an additional hazard because anoxia and hypercarbia develop more rapidly than in nonsmokers. As the anoxia worsens the cell mass undergoes infarction and necrosis.

Regardless of whether these mechanisms of cold injury apply specifically to hypothermia, patients exposed to cold have a multifaceted and variable physiologic response as their core temperature drops. Initially the body increases heat production by releasing stress hormones and increasing the basal metabolic rate; at 35°C the rate may be as much as six times normal. Then, as the temperature drops further, the rate is slowed; at 28°C it is half normal.

Thermogenesis from shivering involves the conversion of adenosine triphosphate (ATP) to adenosine diphosphate, with the release of energy. It has been postulated that there are five other "nonshivering" thermogenic metabolic cycles that involve ATP and phosphorylase in muscles and in other organs.[11-13] As heat is progressively lost from the body surface and the respiratory tract, adaptive mechanisms decompensate and heat production by the body declines until, at 30°C, shivering stops and the muscles become rigid.

As cooling proceeds, the stimulation of cardiopulmonary function that occurred initially is slowly replaced by a drop in both the cardiac output and the respiratory rate. The fall in cardiac output is thought to be the result of local cooling of the pacemaker cells and the Purkinje conduction system, and the slowing of respiration the result of cooling of the respiratory centre in the medulla. Breathing will usually stop at 24°C. In the heart, cooling prolongs the relative length of the PR–QS and PR–QT intervals so that atrial and ventricular arrhythmias occur. An Osborn J-wave following the QRS interval is pathognomonic of hypothermia, but it is frequently absent (Fig. 1).[14] With further cooling the myocardium becomes irritable; ventricular fibrillation and cardiac arrest supervene at around 15°C. During rewarming the heart will usually go through this sequence in reverse, and the arrhythmias that may develop then are sometimes refractory to treatment unless specific measures are taken to rewarm the heart.

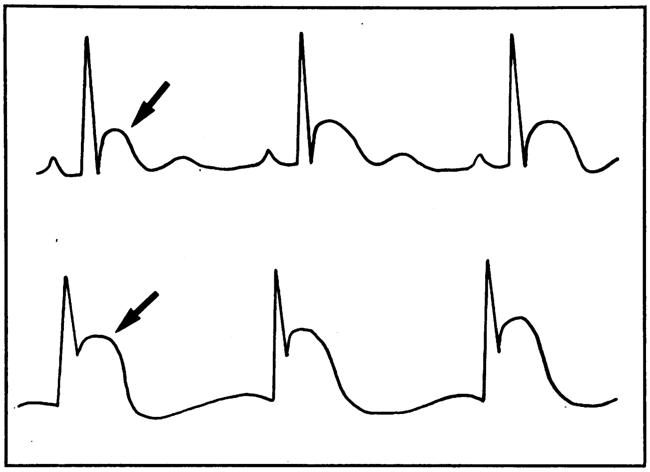

FIG. 1—Osborn J-wave (arrow) following QRS complex, pathognomonic of hypothermia.

In nerve tissue, as cooling proceeds the conduction time is progressively prolonged. The victim begins to have difficulty performing tasks and speaking clearly, and to make errors in judgement; the depressed mentation and coordination signal a decline in function of both the cerebral and peripheral nervous systems. At 32°C the patient becomes unconscious and comatose, and all reflexes cease. Below 20°C the electroencephalogram (EEG) may be flat, mimicking brain death, and in nerve tissue a cell protection mechanism is evoked that acts up to the point of actual freezing. During warming the main hazard is edema of the cerebrum and the spinal cord.

In the kidneys the initial cold-induced polyuria is replaced by oliguria when the cardiac output drops and vasoconstriction produces tubular ischemia. The urine formed is highly concentrated; for mountain climbers and lost snowmobilers who have chronic or subacute hypothermia "dark snowflowers" are a poor prognostic sign.[15]

Erythrocyte agglutination and sludging appear when the viscosity of blood increases. Compartmentalization of plasma and cellular components creates an environment in which a variety of cellular or plasma-factor deficiencies may occur.

The depletion of body reserves of fat, carbohydrate and protein is progressive and is influenced by the release of cortisol, catecholamines and other stress hormones. Respiratory and metabolic acidosis also increases progressively. During and after cooling there is a decrease in hepatic function, especially the detoxification and conjugation of drugs. Insulin production may be decreased during hypothermia, so a high blood glucose level does not necessarily establish a diagnosis of diabetes. After rewarming, deadly acute hemorrhagic pancreatitis may develop.

## Clinical observations

In the United Kingdom, where elderly persons may keep their rooms or homes cool for a variety of reasons, between 11% and 24% of a group of 25 older men and 52 older women surveyed by Fox and colleagues[1] had oral temperatures in the hypothermic range. In another controlled prospective study 10% of a group of 1020 persons ranging in age from 70 to 85 years were found to have core temperatures within 0.5° of 35°C.[5] Other studies have demonstrated that the elderly show both physiologic and behavioural changes that make them more vulnerable to hypothermia. Table I shows routine oral temperature readings obtained in a senior citizens' lodge (once yearly) and in a community hospital (generally morning temperatures) in Peterborough, Ont. It has also been estimated that in the United Kingdom each year 0.5 to 2 persons in every 1000 die of causes related to hypothermia — a possible total of 20 000 to 100 000 annually.[1-5] If these estimates applied to Canada, hypothermia would contribute to between 8000 and 40 000 deaths each year. In fact, in the United Kingdom only about 100 deaths yearly are certified as being caused by hypothermia. Table II shows that relatively few deaths have been attributed, either wholly or partly, to hypothermia in Canada.

The discrepancies between the estimated and actual numbers of deaths certifiable as due to hypothermia in these two areas seem to reflect the failure of authorities to appreciate the importance of cold injury. Often mention of this condition is omitted from a death certificate if the patient has any obvious medical or surgical condition. Hospital statistics also fail to indicate the true incidence of the problem for several reasons. If the attending staff do not measure and record body temperature early, hypothermia may be missed or forgotten once the patient, with a temperature that has returned to normal, is released from the emergency or recovery room. Hypothermia may also be missed because the glass clinical thermometers used in most hospitals are not calibrated below 35°C and will only reflect temperatures this low if the examiner suspects hypothermia and thoroughly shakes down the column of mercury. In some of the cases I have presented, the actual core temperature may have been lower than the records showed — all were the lowest calibrated value that could be read on the thermometers used. The low-reading clinical thermometer, not presently in general use in Canada, should be added to the critical care area of all hospitals so that possible cases of hypothermia can be accurately categorized.

All body surfaces radiate heat to an environment in which the ambient temperature is lower than the body temperature. The rate of heat loss increases when air circulates over the body (loss by convection) or when water covers the body (loss by conduction). If the person is dry the exposed skin is said to freeze in 1 hour at an atmospheric temperature of 10°C. At 4°C one-half of the body's heat production may be lost through the head every hour if it is unprotected. At either temperature a wind of 20 km/h increases fivefold the rate of heat loss by convection. The loss is 20 times as fast if the clothing is wet. The temperature drop with immersion in cold water is 32 times more rapid than with dry cooling. Immersion in water at a temperature of 0 to 5°C results in such a rapid heat loss that in most cases the limbs are useless in 3 to 5 minutes; the patient is comatose in 8 to 10 minutes and may die in 15 to 20 minutes. Following rescue after immersion, core cooling continues as cold blood from surface vessels is fed back into the main

Table II—Number of persons for whom a reduced temperature or frostbite was recorded as a cause of death in Canada and Ontario, 1974 through 1979*

| Year | No. of persons dying of hypothermia (or frostbite): Canada, Male | Canada, Female | Ontario, Male | Ontario, Female |
|---|---|---|---|---|
| 1974† | 86 | 42 | 24 | 9 |
| 1975 | 74 (1) | 33 (1) | 25 (0) | 8 (0) |
| 1976 | 91 (3) | 47 (0) | 36 (0) | 13 (0) |
| 1977 | 85 (1) | 31 (0) | 28 (0) | 8 (0) |
| 1978 | 89 (2) | 23 (1) | 23 (1) | 11 (1) |
| 1979 | 92 (3) | 37 (0) | 26 (0) | 11 (0) |

*Source of data: "Vital Statistics, Causes of Death", cat. no. 84203 (annual), Statistics Canada.
†Cases of frostbite not recorded.

Table I—Body temperatures recorded in a senior citizens' lodge and a community hospital in Peterborough, Ont.

| Subjects (and no.) | Total no. of readings* | No. (and %) of readings: 35°C or less† | Within 0.5° of 35°C | Within 1° of 35°C | Total no. (and %) of readings at or within 1° of 35°C |
|---|---|---|---|---|---|
| Senior citizens (1606) | 1 606 | 10 (0.6) | 55 (3.4) | 301 (18.7) | 366 (22.8) |
| Hospital patients | | | | | |
| Chronic convalescent ward (99) | 4 897 | 62 (1.3) | 130 (2.6) | 876 (17.9) | 1068 (21.8) |
| Medical-surgical ward (840) | 4 064 | 29 (0.7) | 61 (1.5) | 423 (10.4) | 513 (12.6) |
| Pediatric ward (38) | 188 | 0 | 0 | 17 (9.0) | 17 (9.0) |
| Nursery (146) | 453 | 0 | 0 | 0 | 0 |
| Recovery room (143) | 143 | 13 (9.1) | 8 (5.6) | 24 (16.8) | 45 (31.5) |
| Total | 11 351 | 114 | 254 | 1 641 | |

*If the temperature of any patient was read more than once on any one day, only one reading was recorded in this study.
†Indicative of core hypothermia.

blood stream and recirculated centrally. Immersion cooling may also drop the core temperature so rapidly that, even at a core temperature between 15 and 20°C, both respirations and heart beat may cease. When these changes are accompanied by a flat EEG the person may appear, clinically, to be dead. However, cooled cerebral cells may be protected from death for 45 to 60 minutes. Victims of apparent cardiac arrest with hypothermia have been revived through rapid, controlled rewarming after as long as 3 to 4 hours of asystole.[15-19]

The lowest recorded body temperature of a patient who survived without neurologic or cardiovascular symptoms was reported in a woman with pelvic carcinoma whose core temperature remained at 9°C for 1 hour while she was anesthetized.[9]

The categories of hypothermia — acute, subacute and chronic — are difficult to separate. Acute or accidental hypothermia may be so rapid that in a near-drowning or diving accident the changes in the body's metabolic and physiologic parameters are minimal.[8,15,17-19] In subacute hypothermia a healthy person is usually subjected to slower cooling. Because of inadequately insulated clothing or shelter and a lack of protection during mountaineering or cross-country treks, an individual's core temperature may drop. When rescued, such a person may be shivering and suffering from any or all of the following: dehydration, starvation and acidosis, fibrillation, oliguria and frostbite.[15,20,21] Chronic hypothermia is defined as that which occurs in conjunction with an underlying disorder, such as diabetes, alcoholism, myxedema or atherosclerosis, and in persons who are extremely young or old, who have recently lost a considerable amount of body weight, or who are taking various medications and drugs, including tobacco and nonmedical drugs.[7] In cases of chronic and subacute hypothermia, metabolic disorders are frequently severe, and such persons may subsequently become hypothermic even at room temperature or during a surgical operation.

Whatever the physiologic sequence, these patients may present with mild (35 to 32°C), moderate (32 to 27°C) or severe (below 27°C) hypothermia. At a roundtable discussion on mountain climbing, Mills related mortality to these temperature categories: he reported rates of death of 25%, 52% and 66% (overall 49%) for his patients with mild, moderate and severe hypothermia respectively, all of whom were treated by surface rewarming.[15] In another small series of his, in which the treatment was core rewarming, all seven patients survived.[21] In other series mentioned in the discussion, in which rates of death ranged from 30% to 80%, the deaths were related more to underlying disease than to the initial core temperature or the mode of treatment.[15-21]

## Treatment[15-35]

Surface rewarming includes any of the methods of applying heat to the body through the skin. With mild hypothermia surface rewarming is often the ideal treatment. However, surface rewarming in moderate or severe hypothermia may worsen an already precarious clinical situation. The core temperature may be depressed further if cold sequestrated fluids are recirculated from the surface into the core blood stream. The opening of peripheral vascular beds often induces hypotension and the heart may become overloaded; it may also be damaged by tissue metabolites released from these beds. The shivering that may occur at body temperatures of 30 to 35°C may increase the heart rate and depress the blood glucose level. Also, although it produces heat, shivering increases the return of cool blood to the core, and so may interfere with the patient's management; it should probably be stopped by medication if the patient is comatose, though it may be allowed to continue if the patient is alert and cooperative.

Surface heat loss is maximal from the three areas — the lateral chest wall, the neck and the groin. The most effective method of surface rewarming is immersion in water heated to a temperature no higher than 42°C. Almost as effective is the application of hot water bottles heated to 42°C to the areas of maximal heat loss.[22] For some patients with hypothermia, active rewarming with heated wool, electric or hypothermia blankets, heat lamps or heated room air, or passive rewarming with insulated covers that retain body heat may also be useful.

Core rewarming includes methods of raising the body temperature by inserting heated material into a body cavity or into an organ. In cases of severe hypothermia, core rewarming may be the only means of returning warmed blood to vital centres without the physiologic complications that may accompany the slower surface methods.

Core rewarming may be either invasive or noninvasive. It is alleged that the loss of core heat is greatest from the nasopharynx and the respiratory tree. If spontaneous ventilation is possible, the nasopharynx and the trachea down to the carina may take part in the rewarming process if the inspired air is humidified and heated to a temperature no higher than 46°C. If intubation and positive pressure ventilation is necessary the heated, humidified air will warm the pulmonary alveolar beds and increase the efficacy of the heat exchange process.[32-34] If tubes are inserted into the stomach, bladder or colon, irrigations with fluids at a temperature no higher than 42°C will rapidly raise the core temperature. Warmed intravenous solutions will also contribute to core rewarming.

Invasive core rewarming may include peritoneal lavage, mediastinal or thoracic lavage and partial cardiopulmonary bypass.[28-31] It has been reported that lavage with 2 l of a dialysate heated to 38 to 40°C, instilled and exchanged every 30 minutes, may revive victims of severe hypothermia.[19,28,29] Irrigation of the chest, mediastinum or pericardium with isotonic solutions heated to a temperature no higher than 42°C will rapidly rewarm the core.[16,19,29] However, because this procedure may precipitate cardiac irregularities, it should be done only in an operating room. Cardiopulmonary bypass will also raise the core temperature rapidly, but this procedure requires facilities and expertise not often available in small hospitals.[30,31] As a general rule, patients with severe hypothermia will require more vigorous and perhaps invasive measures, whereas those with mild hypothermia may need only general support and passive rewarming with an insulating blanket.

## Discussion

Hypothermia, perhaps more than any other traumatic condition, is preventable. Most instances of accidental hypothermia, especially in the elderly and in patients recovering from an operation, could have been avoided by foresight and the application of common sense.

Attempting to rescue a hypothermia victim and apply first aid may tax the rescuer's physical stamina and ingenuity. In many instances it may seem better to bring first aid to the victim than to attempt a hazardous evacuation. A move from the cold environment to shelter is often essential for the survival of both the victim and the rescuer. If the victim is in, or is threatened with, cardiac arrest, cardiopulmonary resuscitation must be started at once and continued as the rescue proceeds. Patients in whom cardiac arrest with hypothermia has persisted for up to 3 or 4 hours have been revived by rewarming and cardiopulmonary resuscitation. Rescuers should be aware that for severely hypothermic victims the rate of cardiac massage may be as low as once every 2 seconds and the rate of ventilation once every 10 seconds. Although cerebral recovery may not occur as quickly as the return of cardiac function, this variance is never apparent initially. In any case, an apparent deficit in cerebral function should never deter attempts at resuscitation. Unconscious victims should be actively rewarmed by applications of surface heat to the lateral chest wall, neck and groin. A portable thermal blanket, which can be heated from a catalytic heater or a rescue vehicle, may be invaluable in treating victims of near-drowning or diving accidents. A portable humidifier heater, a variation of the Bennett Cascade Humidifier (Puritan Bennett Corporation, Kansas City, Missouri), which supplies warm, humid air, has recently become available for use in the field.[32,33] If no other heat source is available, the rescuer's own body heat may be lifesaving. Conscious victims should be given warmed fluids, if these are available, and surface heat as needed. Victims should be transported to hospital as quickly as possible without causing further trauma. In evacuations by helicopter or sled the victims should be kept flat because a sling or a sitting position may worsen shock. Frostbitten victims are usually not rewarmed in the field, but frozen hands and feet should be protected from trauma and further cold.

In hospitals cold injury must be suspected and a proper diagnosis made before treatment can be started. Low-reading thermometers are required, and readings should be taken from the esophagus, rectum or auditory canal; those from the mouth are less satisfactory. All persons with a presenting temperature below 35°C should be kept in hospital. A record should be made of the circumstances and apparent length of the exposure, and any frostbite, including details of the colour, temperature and texture of the frozen part, should be noted. Appropriate warmed fluids should be administered through large-bore intravenous or central venous pressure lines, and the following biochemical studies should be ordered: complete blood count, blood gas analysis (with results corrected for the patient's temperature), and measurement of serum levels of electrolytes, amylase, urea and glucose. Arterial catheters, if available, will greatly simplify sequential blood sampling and the monitoring of vital signs. Tubes should be ready for gastric, bladder or colon intubation in case it is necessary to irrigate these areas with warm fluids. The patient who is breathing spontaneously should be given, by mask, oxygen that is humidified and warmed to a temperature no higher than 46°C. If ventilation or hyperventilation is required, nasotracheal intubation and the use of heated, maximally humid air containing 70% oxygen is superior. The patient may require bicarbonate or other buffers for acidosis, dextran 40 (Rheomacrodex) for sludging, mannitol (Osmitrol), dexamethasone (Decadron) and other agents for cerebral edema, and antibiotics to prevent pneumonia or sepsis. Coexisting disease should be treated appropriately as it is recognized.

Active rewarming should be stopped when the core temperature reaches 32 to 35°C. The patient should then be watched carefully because reflex recooling or

GUIDE TO INITIAL THERAPY OF HYPOTHERMIA

1. Take rectal temperature. Thermometer should be available to measure low temperatures, often as low as 20 C.
2. Hypothermia exists when the core temperature is 35 C or below.
3. All such patients should be admitted until stable.
4. In addition to the usual medical or surgical history, obtain a history of the circumstances of exposure, length of time, and pre-hospital treatment.
5. Initiate large bore intravenous line or lines and start infusion with warmed intravenous fluids.
6. Order baseline biochemical studies - CBC, electrolytes, BUN, blood sugar, amylase, pH and blood gases. The pH and blood gases must be corrected to the patient's temperature.
7. An arterial line will simplify monitoring and blood sampling.
8. If patient is breathing, give oxygen by mask with maximal humidity and warmed to 46 C.
9. If patient is in respiratory distress intubate nasotracheally and administer 70% oxygen with maximal humidity and warmed to 46 C.
10. Optional treatment may include bicarbonate or other buffers for acidosis; low molecular weight dextran for capillary sludging; mannitol/decadron to reduce cerebral edema; and prophylactic antibiotics.
11. Make a notation of frostbite with colour temperature and texture of the skin. Mark affected areas on figures on chart.
12. If frostbite has not been rewarmed immerse in water no warmer than 42 C With return of colour, warmth and tissue turgor, dry the skin and treat like a burn.
13. If there is any question of cerebral edema likely to cause irreversible brain damage, DO NOT REWARM. The patient should be resuscitated and sent to a unit familiar with controlled hypothermia.
14. Treat any medical or surgical problems concomitantly.

REWARMING METHODS

SURFACE

Active - Immersion of body in water bath no warmer than 42 C.
Application of hot water bottles no warmer than 42 C to lateral thoracic wall, neck and groin.
Warmed humid air by mask heated to 46 C.

Passive - Retention of body heat by blankets or warmed blankets.

CORE

Noninvasive - warmed IV solutions
- irrigation of stomach, bladder or colon with water heated to 46 C
- warmed humid air given by endotracheal tube heated to 46 C.

Invasive - Peritoneal lavage consisting of 2 litres of 1.5% Dianecl heated to 40 C given every 30 minutes
- Thoracic or mediastinal lavage using saline heated to 40 C
- Partial cardiopulmonary bypass.

APPROXIMATE TEMPERATURES

| | |
|---|---|
| 35C | Hypothermia |
| 34C | Ileus |
| 32C | Coma |
| 35-30C | Shivering |
| 30C | Muscle rigidity |
| 27C | Ventricular fibrillation |
| 24C | Respiratory arrest |
| 20C | Flat EEG |
| 15C | Cardiac arrest |

**FIG. 2—Protocol for early management of hypothermia.**

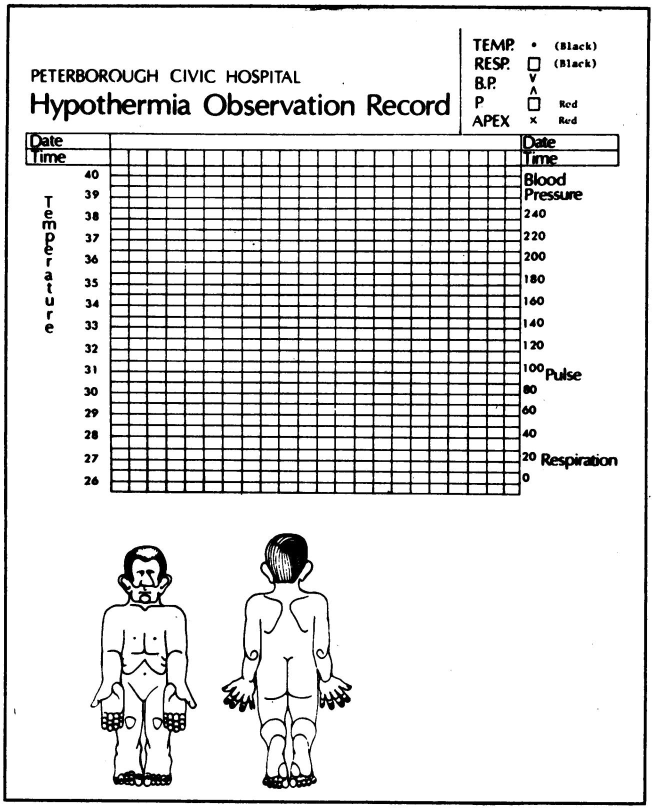


**FIG. 3—Form for use by nurses in recording patient's progress during first few hours of treatment. The figure, which is for recording frostbite, emphasizes areas most frequently affected.**

hyperthermia may develop. If coma persists or recurs, especially in victims of near-drowning in cold water, the attending physician must make a decision either to continue the rewarming process[35] or to convert to a routine of controlled hypothermia to protect cerebral function.[8]

In an attempt to remind staff in the critical care areas of Peterborough Civic and St. Joseph's General hospitals, Peterborough to watch for low temperatures, a sign reading "Hypothermia" has been attached to the wall under the main clock in each such area. As well, a form has been designed that provides on one side a protocol for the early management of hypothermia (Fig. 2) and on the other side space to record the patient's vital signs (Fig. 3). The form has been very helpful during treatment and invaluable for gathering statistics afterwards.

Frostbite can occur with hypothermia. If the patient's cardiopulmonary status is stable or becomes stable with treatment, the physician needs a plan for managing the local cold injury. The aim of initial care is to rapidly restore the involved part to a near-normal temperature, thus minimizing the cold injury and improving the microcirculation. In children early treatment is more urgent because extreme cold can damage the epiphyseal growth plates and necessitate orthopedic care later.[36] If the frostbitten part has not yet rewarmed, it should be immersed in water of a temperature between 35 and 42°C. When normal colour, warmth and turgor have returned, the skin should be gently dried, the part elevated and the injury treated much like a burn except that there is no hurry to debride or amputate. "Immersion foot", a rarer condition, is managed like frostbite.

## Conclusions

The recent literature stresses the insidious nature of hypothermia, especially in the elderly; this observation was substantiated by my survey of hospital patients and elderly residents of a senior citizens' lodge. About 1% of those surveyed were hypothermic and about 20% had a body temperature within 1° of 35°C.

Patients in critical care areas of a hospital — the emergency room, intensive care units, operating rooms and recovery rooms — are vulnerable to hypothermia and thus to the gross physiologic abnormalities associated with this condition. Assuming that 1% of a hospital's population is already hypothermic and that 10% to 20% more are within 1°C of being hypothermic, it may be postulated that a sizeable proportion of surgical patients are at risk of hypothermia when, fasted, dehydrated and sedated, they are left lying in a cool hall on a stretcher waiting for their operation. Temperature monitoring in the operating room is becoming routine, and this practice must be encouraged.

The staff of hospitals in cold climates, smaller hospitals in particular, need a better understanding of cold injury, especially in view of the increased participation in winter recreation and the rising prices for heating fuel. All hospitals should have low-reading thermometers, and the staff in each critical care area should periodically review the diagnosis of hypothermia. Once the condition has been recognized, prompt and effective treatment of hypothermia requires that the patient's core temperature be categorized and that the appropriate passive, active or invasive rewarming techniques be used to restore the body temperature to normal.

In completing death records, medical practitioners should consider whether hypothermia was the cause, or associated with the cause, of death, especially in unexpected deaths during inclement weather and in the elderly. With an increased awareness of hypothermia by health care personnel and the compilation of more reliable data on its incidence, it is possible that the condition will be found to cause more disability and death in cold-climate hospitals than has previously been apparent.

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