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Emergency Mediciney

Cold Injuries

Witold Kurnatowski[1], Włodzimierz Ostaszewski[2], Radosław Ziemba[3], Ewa Ziemba[4], Katarzyna Parzuchowska[3], Adam Ziemba[5]

[1] Province Station of Rescue Ambulance Service in Warsaw, Poland
[2] Medical University in Łódź, Poland
[3] Military Centre of Pharmacy and Medical Technique in Celestynów, Poland
[4] Institute of Psychiatry and Neurology in Warsaw, Poland
[5] Military Medical Institute, Warsaw, Poland

Author's address:
Radosław Ziemba, Military Centre of Pharmacy and Medical Technique, ul. Wojska Polskiego 57, 05–430 Celestynów, Poland; e–mail: zx11@op.pl

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Summary:

Significant hypothermia is an increasing clinical problem that requires a rapid response with properly trained, well-equipped personnel. 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 (42–46 °C), to help stabilize core temperature. If possible, core temperature and cardiac rhythm should be monitored in the pre-hospital setting and CPR should be continued during transport. In-hospital management should consist of rapid core rewarming of a severely hypothermic victim with heated humidified oxygen (42–46 °C), centrally administered warm IV fluids (40–43 °C), and peritoneal dialysis until extra-corporeal rewarming can be accomplished. Post-resuscitation complications should be monitored; they include pneumonia, pulmonary edema, cardiac arrhythmias, myoglobinuria, disseminated intravascular coagulation and seizures. The decision to terminate resuscitative efforts must be individualized by the physician in charge.

Key words: hypothermia – initial management, ventilation with warm air/oxygen, administration of warm IV fluids, peritoneal dialysis, extra-corporeal rewarming of blood

Current methods of hypothermia management yielded many unpleasant experiences suggesting that emergency services providing first aid should be properly trained and provided with appropriate technical equipment in order to effectively and rationally save lives and prevent deaths.

Every year, with the advent of cold autumn weather, we receive information that people die of hypothermia even though "true" frost has not come yet. According to the reports by the mass media (based on the data acquired from the Polish Police Headquarters – more recent data is not available – W.K.) during autumn 2002, before the commencement of winter (from mid-September until mid-December), 214 people lost their lives because of to hypothermia.

As this information was not based on statistical data it should be presumed that the true number

of cold victims until the beginning of spring 2003 was much higher.
This data was quite surprising for many of us because the frosts were yet to come and temperatures well below 0 °C were not expected until January, February and March.

In January 2006, until the 23rd day of the month, over 240 people died due to hypothermia during cold weather with temperatures persisting below -20 °C (Table 1).

Table 1: Fatalities due to hypothermia

Years	Fatalities
2005/2006	240 **)
2004/2005	90 *)
2003/2004	314
2002/2003	312
2001/2002	305

* Data gathered until the end of January 2005 – announced by TVN
** Data from the end of January 2006 announced by the mass media

Past several winters in Poland were not very severe and the few cold fatalities did not create the need to conduct prophylactic actions in that subject. Consequently, surgery and anesthesiology textbooks also devoted too little space to thermal injuries.

Both medical school alumini as well as doctors without direct contact with cold victims do not always know how to provide aid using modern techniques [1-5]. Reducing the number of hypothermia victims depends not only on prevention, first aid training and advancement of therapeutic methods but also on proper technical equipment [6-10]. One should remember that almost every life of a cold victim in Poland could have been saved if medical aid had been provided in time. Knowledge, experience as well as providing emergency services with appropriate technical means are necessary in order to effectively combat the aftermaths of the cold.

Effects of cold temperatures on human body

Systemic effects exerted by the cold on human organism and impeding function of vital organs are referred to as *hypothermia*.

General awareness of the topic should increase proportionally to the development of car industry, mountaineering as well as winter and water sports.
Prevalent, erroneous opinions laying at the background of our notions regarding hypothermia strengthen our beliefs such as the one that remaining in water for more than 5 minutes must result in death. Clinical experience indicates that a human can survive longer in cold water than it was believed until now [10].
A significant number of people who "drowned" in ice-cold water and were retrieved led doctors to change their views on hypothermia and inclined them towards continuing rescue actions in such cases [11,12].

Hypothermia may also affect victims with multiorgan damage and shock sustained in traffic accidents, which may happen not only during period of cold weather but also in the summer. One must be also aware of the possibility of hypothermia occurring during mass accidents (not only earthquakes, war or shipwrecks) [13].

For the past few years, in an era of terroristic attacks that may take place all around the world, it must be taken into consideration that victims exposed to hypothermia due to low temperatures or cold water may require proper and effective first aid in every location and at every time of the year.

There is also a question worth asking – what is the reason for an increasing number of victims of hypothermia in Poland each year?
In recent years the homeless, unemployed, elderly and sick as well as alcohol – and drug-dependent people increasingly often have become victims of cold weather.
The following factors contribute to hypothermia and frostbite occurrence – malnourishment, chronic and wasting diseases, convalescence following an illness or injuries with sustained blood loss, cardiovascular diseases.

Local injury due to low temperatures, causing damage to cells and tissues exposed to the cold is called **frostbite**. It may occur in humid, windy weather, even when air temperature remains above 0 °C.
Exposed parts of the body are at the greatest risk of frostbite: face, ears and nose, hands as well as feet. Immobility and tight or wet clothing also

contribute to the injury. Shoes that are wet or that constrict toe motions and impede blood flow also play a role in development of frostbite.
There are also chilblains, which are formed as a consequence of long-term exposure of tissues to low temperatures. [3, 4, 6, 9, 13]

Hypothermia

Sometimes the cold victim is still alive when found but dies when we begin to administer first aid even though hypothermia is not accompanied by other injuries or illnesses.

Hypothermia – is characterized by lowering of core body temperature to 35 °C or less. It is a result of reduced ambient temperature, at which human organism is unable produce sufficient amount of heat necessary for proper functioning. It is a life-threatening state, which can be fully prevented [2, 5-8].
It may be caused by: staying in open spaces at low temperatures without appropriate protection from the weather, immobility, trauma or post-traumatic shock, cold water below 21.1 °C.

The following are the signs of impending hypothermia:
- shivers as signs of heat loss,
- disorientation and memory loss,
- sleepiness and feeling of exhaustion,
- impairment of motor coordination,
- slurred speech,
- numbness.

The following signs herald hypothermia in children:
- bright-red and cold skin or
- signs of apparent death.

The following factors increase the risk of death due to hypothermia:
- air temperature below +10 °C,
- alcohol abuse or acute intoxication,
- drug use,
- psychiatric disorders, Alzheimer's disease,
- insufficient body cover and wet or damp clothing,
- age: below 15 or above 65 years,
- malnourishment and homelessness.

Cooling the body to 35 °C or less results in cardiac arrhythmias, slow and shallow breathing. Acidosis develops as a consequence of slowed down blood flow through the tissues and decreased gas exchange.

Stages of hypothermia

Hypothermia can be distinguished into the following stages:
- **mild hypothermia with body temperature ranging from 34 °C to <36 °C** accompanied by:
  - shivering,
  - loss of motor coordination,
  - moderate disorientation,
  - at 36.0 °C metabolic rate increases,
  - at 35.0 °C shivering intensifies, victim is unable to properly assess the situation.

- **moderate hypothermia with body temperature ranging from 30 °C to 34 °C** accompanied by:
  - clouding of consciousness at 33.0 °C
  - cessation of shivering and mydriasis at 32.0 °C
  - blood pressure may be difficult to determine at 31.0 °C.

- **severe hypothermia with body temperature of 30 °C or less** accompanied by:
  - **at 28-30 °C:**
    - bradycardia and decreased respiratory rate,
    - increased muscle stiffness,
    - loss of consciousness,
    - ventricular fibrillation.
  - **at 27.0 °C the findings are:**
    - loss of deep tendon, skin and vascular reflexes,
    - signs of clinical death,
    - asystole.

Sometimes the cold victim is still alive upon finding but dies when we begin to administer first aid even though hypothermia may be unaccompanied by other injuries or illnesses. It indicates that our experience in that subject is insufficient and treatment is sometimes wrong or unsuitable.
There have great advancements in this area of medicine for the past several years. [15]

People with symptoms of hypothermia should be provided with prompt medical attention immediately after they are found. However, before medical services arrive, the hypothermic patient should be:
- placed in a well-heated room,
- protected from further effects of weather

conditions,
- stripped of wet clothing,
- the following areas should be warmed first:
  1) chest,
  2) head and neck,
  3) inguinal areas – heat sources such as electric blankets, hot water bottles, etc. should be placed there all the while protecting the skin from burns. [13,14]

Rules of conduct at the site of an accident – life-saving.

The goal of these interventions is to ensure survival of hypothermic victim. Therefore:
- medical personnel should in any case consider the degree of hypothermia during administration of first aid,
- all emergency medical teams should be outfitted with necessary equipment for warming patient as well as thermometers allowing measurements of body temperature around 30 °C or lower (on the tympanic membrane, in the esophagus or rectum).
- emergency medical teams working in low-temperature areas (GOPR – Mountain Volunteer Rescue Service, WOPR – Water Volunteer Rescue Service) should also have proper equipment and experience in warming patients.

It was established that the most critical period of time for medical personnel administering aid to a person in hypothermia is the first 30 minutes from the moment of finding her/him because during that time:
1) the hypothermic victim must be kept alive,
2) body temperature must be sustained and protected from decreasing any further,
3) patient must be transported from the site of an accident to a specialist medical center as soon as possible.

Hypothermic patients are often victims of traffic accidents, construction disasters or building collapses and reaching them is not always easy. General condition of a patient with multiple injuries often does not allow transfer with just any mode of transportation without proper stabilization. Sometimes, rapid transportation of a victim from the site of an accident outdoors to hospital is not possible and treatment must be initiated immediately at the site. [15]

In such instances one must proceed effectively and remember that due to progressive reduction of body temperature **all vital functions:**
- heart rate,
- respiratory rate,
- metabolism, or
- cognitive function
- gradually slow down.

Hypothermia may also lead to development of other symptoms. Therefore, medical personnel must pay attention to:
- pulse – counted for at least 45 seconds – slowing down or becoming irregular,
- breaths – becoming slow and shallow,
- speech slowing down,
- lack of response to verbal or painful stimuli,
- reduced ability to move,
- skin becoming cold and
- decreasing rectal temperature.

Patients may present with other changes, which cannot be identified at the site of an accident and indicate poor prognosis. These are:
- biochemical changes in peripheral blood,
- change in oxygen and carbon dioxide content in blood,
- heart rate becoming irregular,
- hypovolemia,
- distinct difference between skin and rectal temperatures.

Patient management directly at the site of the accident

Pre-hospital care at the site of accident should be administered according to a simple scheme and an established management plan, which takes into consideration all stages of hypothermia (Table 1).

Patient should be placed in a horizontal position in order to prevent orthostatic fall in blood pressure. It may also occur as a result of inflow of cold blood from extremities to the heart leading to development of cardiogenic shock. Horizontal position is supposed to facilitate proper perfusion of central nervous system and cerebral cortex despite the lowered blood pressure. This position is also important for patients retrieved from water, who often suffer from sudden hypotension [12-15].

Hypothermic patient should be supplied with pre-warmed, humidified oxygen or air. This is

a well-established method of "core rewarming" used for many years not only in the United States, Canada and Australia, but also in Europe.
Hypothermic but conscious patients should be given hot, sweetened or high-calorie drinks without alcohol or caffeine. Alcohol dilates skin vessels leading to increased loss of heat from patient's body to the environment through radiation, and caffeine, through its diuretic effect, decreases the volume of circulating blood.

As patient's temperature may still decrease despite rewarming, it requires constant monitoring. At this stage, preventing further heat loss is the prime challenge for the rescue team [16].

Prevention of cardiogenic shock

Before initiation of shock management, the patient should be thoroughly examined.

One should remember the basic ABC rule of management:
A = (airway) – checking patency of the airways,
B = (breathing) – sustained breath – ensuring proper breathing,
C = (circulation) – preserved circulation – restoration of heart rate and blood pressure.
In hypothermic patients there is also:
D = (degree) = degree of hypothermia (body temperature measurement).

Vital functions should be thoroughly examined:
- pulse and heart rate (for at least 45 seconds),
- respiratory rate,
- blood pressure,
- body temperature, e.g. on the tympanic membrane, in the oral cavity or rectum.

Attention: One should also remember that measuring body temperature with traditional mercury thermometers does not yield results adequate with those taken with special thermometers designed for measuring temperatures below 35 °C in the esophagus or on the tympanic membrane.
- assess: state of consciousness, pupil width and reaction to light, answers to questions and clarity of thought – it may be helpful for diagnosing severe hypothermia,
- while examining the patient, one should remember that pain perception is reduced in those patients and it is necessary to conduct routine physical examination in order to exclude: additional traumas, frostbites, damage to soft tissues, fractures, etc.
- Proper management should be initiated if any of the above is found.

Life-saving interventions

Patients diagnosed with sole bradycardia do not require cardiopulmonary resuscitation. However, it should be immediately initiated in those retrieved from cold water.

Cardiopulmonary resuscitation should be initiated always when necessary and when indications for it exist (Table 2).

Table 2: Hypothermia* – management plan at the site of the accident

	Symptoms	Menagement
37.5ºC	Normal body temperature measured in the oral cavity.	
	Mild hypothermia: body temperature from 34 to < 36ºC	
36ºC	Perception of cold	Change the wet clothing for warm and dry one, put on warm socks, a hat and a scarf, goggles. Protect the head and neck from the cold, perform physical exercise. External warming: a bath, fire – only with body temperature higher than 35ºC.
35ºC	Shivers	Administer high-calorie, hot and sweet drinks, but no alcohol or caffeine.
	Moderate hypothermia: body temperature from 30ºC to 33.9ºC requires administering first aid and hospital treatment	

	Symptoms	Menagement
34ºC	Unstable gait, disorientation, Apparent alcohol intoxication.	Do not perform excessive, rapid movements. Do not warm externally apart from the chest and trunk.
33ºC	Muscle stiffness	Administer hot, sweet drinks. Administer air/oxygen humidified and warmed to 42-46ºC.
32ºC	Cessation of shivers	Monitor heart rate and breathing. Protect from arrhythmias.
>32ºC	Cessation of shivers - cardiovascular collapse - urgent transportation to hospital	
31ºC	Semiconscious	Do not ad minister food or drinks.
Severe hypothermia: body temperature below 30ºC requires administration of first aid and hospital treatment		
30ºC	Unconscious Lack of response to verbal and painful stimuli	Do not administer anything orally. Maintain airway patency, oro-pharyngeal tube, safety position, changing body position every 2 hours to avoid formation of decubital ulcers. Monitor pulse and breathing.
29ºC	Bradycardia and bradypnea	Initiate mouth-to-mouth breathing support according to the rate of patient's own breaths (slow and shallow breathing).
28ºC	Cardiac arrest Lack of pulse and breaths, pupils dilated	Maintain airway patency, carry out mechanical ventilation using mouth-to-mouth (through a mask) or mouth-to-nose method; maintain 12-15 breaths / min. and 80-100 chest compressions / minute.
27ºC	White-gray, cold skin	Do not stop administering first aid! Continue resuscitation as long as you can.
Severe hypothermia: body temperature below 20ºC requires administering first aid and hospital treatment		
>20ºC	Patient is not presenting any signs of life	Do not quit administering first aid!
Remember about calling the emergency services to every cold victim! PROTECT THE PATIENT FROM BOUNCING/SHAKING IT MAY LEAD TO CARDIAC ARREST		

* Hypothermia – body temperature below 36.0ºC (thermometer for measuring body temperatures below 36.0ºC).

In such cases mouth-to-mouth ventilation using a mask is the best method as it provides the victim with humidified, warmed air exhaled by the rescue worker. Warmed and humidified 100% oxygen can be also administered through a warmer powered from a car battery or a 12V power supply in a car, an ambulance or a helicopter (Figure 1).

In case of ventricular fibrillation in a hypothermic patient, we immediately administer three subsequent shocks from a defibrillator and, if ineffective, proceed with CPR and patient rewarming. If the victim's body temperature remains below 30 ºC, defibrillation and drugs given during cardiopulmonary resuscitation may prove ineffective. Hypothermic heart is unresponsive to

Figure 1:

electrical stimuli and the heart muscle may be damaged with too frequently repeated shocks. Drugs, on the other hand, will not exert an effect

on a cold heart muscle because their metabolism is slowed down in the hypothermic liver. Therefore, they will accumulate and exert their effects upon rewarming of the patient, which may result in toxic concentrations of antiarrhythmic agents [8]. Their amounts should be decreased and intervals between subsequent doses prolonged.

Initiation of resuscitation, moving or repositioning of the hypothermic patient must be conducted very carefully. Massaging or putting pressure on her/his limbs is prohibited as it may relocate cold blood with accumulated waste products from patient's limbs to central circulation. Heart may respond to contact with cold venous blood from peripheral circulation (with low pH) with an arrhythmia or asystole, which may end tragically for the patient.

Methods of patient rewarming

Basic methods of rewarming hypothermic patients are:

- **passive – external – rewarming method (PER = passive external rewarming)**, used in: mild and moderate hypothermia. It reduces heat loss to a minimum through covering the patient with blankets and insulating material – it is effective during persistent shivers and ambient temperature above 21 °C. The advantages of this method are: non-invasiveness, simplicity and maintaining contractions of peripheral vessels. It may be used in deep hypothermia, as an auxiliary method;

- **active method:**
  - **external – transdermal rewarming – (AER = active external rewarming)**, when heat is transferred directly onto the skin through placing heating packs (chemical reaction) or hot water bottles in axillary fossae, alongside of the arms, chest and abdomen as well as inguinal regions, but also by using heating lamps, electric blankets and sleeping bags warmed with a stream of hot air. Active external rewarming is recommended only in moderate hypothermia because the heat transferred to the tissues stimulates peripheral circulation. **It may be effective when used together with core rewarming (ACR) in severe hypothermia**;
  - **internal – core – body rewarming (ACR = active core rewarming)** is the basic therapeutic management of severe hypothermia: cardiac arrest, unconscious patients, bradycardia. It includes: ventillation with warmed oxygen/air, which should be used already in pre-hospital care. Infusing warmed fluids into large veins, peritoneal dialysis or hemodialysis with warmed fluids, rinsing pleural cavities, gastric or intestinal lavage using warm fluids.
- **active – internal – method of body rewarming in severe hypothermia together with active transdermal rewarming** can be more effective, although heat should be directed at the thorax only. Warming of the extremities causes: increased metabolic rate in the periphery and increased hemodynamic demand.

Methods mentioned above diminish the patophysiologic effects of rewarming. [8]

However, clinical experience demonstrated that application of **active external rewarming** in cases of **severe hypothermia** before core rewarming and initiated cardiopulmonary resuscitation leads to increased metabolism and cellular oxygen demand. Often, it is even the cause of myocardial infarction and increased mortality in patients undergoing such treatment compared to those receiving active core rewarming.

Active external rewarming increases the flow of cold blood from peripheral vessels e.g. lower limbs and their muscles, through the heart. Therefore, it may be expected that such interventions will result in deepening of hypothermia in vital organs, especially the heart

Rewarming methods

Ventilation with oxygen/air warmed to a temperature 42-46 °C transmits heat not only to the face, nose, throat and neck, but also to the blood vessels located proximally to the airways that carry blood to the brainstem containing many vital centers. Heat transmission may be increased through intubation.

Such interventions quickly lead to rewarming of the central nervous system, regaining consciousness and stimulation of functions of centers regulating: breathing, thermoregulation and heart rhythm. It also causes gradual warming of thoracic organs: lungs and heart. It prevents further

heat loss from the hypothermic organism caused by respiratory heat loss.

Inhalation rewarming is non-invasive and may be initiated at the scene of the accident and performed without any waste of time throughout the way to hospital and continued on arrival.

Active external rewarming – using an electric blanket powered by a 12V (from a VRLA gel battery, a car cigarette lighter socket or a 230/12V transformer) or a 230V power supply. Heat is transferred directly from a blanket to the trunk – chest and abdomen – but not the limbs, to avoid a "thermal shock." (Figure 2.)

Figure 2: Electric blankets powered with 12V or 230V supply.

Extracorporeal rewarming: extracorporeal circulation, hemodialysis with regulated blood temperature.

Administering infusion fluids warmed up to temperature 40 – 43˚C via large veins .
Lavage with warm fluids: stomach, colon, pleural cavity, peritoneal dialysis.
Storing medications and infusion fluids at 15-30˚C in special, insulated, electrically heated containers. Using cold drugs while administering prehospital first aid may cause additional reduction in patient's temperature.

Effectiveness of rewarming

There are various ways to accelerate and increase the effectiveness of rewarming of the hypothermia victim:

- ***Active external rewarming*** – using an electric blanket powered with a 12V (VRLA gel battery, car cigarette lighter socket or 230/12V transformer) or a 230V power supply, hot water bottlers, warm bath or packs releasing heat of +37˚C (chemical reaction) – **we can achieve *core rewarming* at the rate of 0.5 ºC – 1 ºC per hour.**
- ***Ventilation with air/oxygen humidified and warmed to 40.5-42.2˚C* – we can achieve *core rewarming* at the rate of 1 ºC to 2.5 ˚C per hour.**
- **Central administration of fluids warmed to 40-42˚C** such as 5% glucose solution in 0.9% saline or 5% glucose ***at 150-200 ml/hour* – we can achieve gradual *core rewarming* at a rate of 0.5˚C to 1˚C per hour.**

- **Peritoneal dialysis with potassium-free fluids warmed to 40.5 – 43.3˚C, (maximally 2L at a time) – we can achieve core rewarming at a rate of 2.5˚C per hour.** However, it is associated with the risk of infection or bleeding and requires large amounts of dialysis fluid.

- **Lavage:**
  - ***of the stomach and urinary bladder with fluids warmed to 40 – 42˚C, or***
  - ***pleural cavity with fluids warmed to 40 – 42˚C* –we can achieve *core rewarming at a rate of* 2.5˚C per hour.**

- ***Extracorporeal circulation* – we can achieve core rewarming of 1˚C to 2˚C – for every 5 minutes** at a flow rate of 2-3 liters per minute.

- ***Using hemodialysis* – we can achieve core rewarming,** although this method is significantly slower and less effective than extracorporeal circu-lation. [17-20]

Further treatment

Acutely hypothermic patients often require fluid infusion into central veins before being transferred to the Emergency Department in order to fill the vascular bed. Great water loss occurs under such conditions due to evaporation and sequestration of fluid into the "third space." There are difficulties in maintaining proper blood pressure. Interventions that restore the volume of circulating blood may be also used when hypotension is due to its substa-ntial loss.

Venous catheters, infusion sets, urinary catheters as well as endotracheal tubes alike should be protected from the cold before their use and stored in heated containers. (Figure 3)

Infusion fluids: should be warmed before as well as during administration (to the temperature

Figure 3: Heated container.

of 40-43˚C) in order to protect the heart from further cooling.

Bottles containing infusion fluids and infusion sets: should be placed in a device that warms both the bottle and the tubing along its entire course – from the bottle to the puncture site.
Such warming dev-ice may be powered by a portable battery or a 12V power supply in an ambulance. It should protect the patient from infusion of cold fluids and effects of ambient cold air. Therefore, it should effectively prevent deepening of hypothermia.

A protector insulting the bottle and infusion set from the surrounding cold ensures that hypothermia victim receives warm fluids. It also helps avoid heat loss and protects fluids from cooling. Infusion of warm fluids increases body temperature and contributes to stabilization of general state of the hypothermic patient (Figures 4).

In cases of severe hypothermia with asystole the rescue team is focused on cardiopulmonary resuscitation and quickly transferring the patient to hospital for rewarming and further resuscitation. Treating such individuals outside the hospital is controversial.

Patients should be carefully covered with blankets or placed in sleeping bags prior to transportation on an airplane or by a helicopter. Their heads should be protected from cold air generated by a helicopter rotor [21] as this is the way organism loses 22% of heat (Figure 5).

Monitoring of heart rate, respiratory rate and temperature should take place during the entire time of transportation and resuscitation equipment should be always ready for use.

During transportation, the patient should be supplied with humidified, warmed oxygen/air for active core rewarming. It is a very important factor for treatment of hypothermia, stabilizing patient heart, lung and brain temperatures.

Figure 4: Protector insulting

An unconscious patient should not receive any drugs or fluids orally until regaining consciousness and ability to swallow.
Hot drink supplementation is not sufficient for warming patients in severe hypothermia. However, they may be helpful in treatment of moderate hypothermia.

Figure 4: Blanket and sleeping bag

Hypothermic patients – after gaining intravenous access – **should be given infusions of fluids warmed up to 40-43˚C:**

- 5% glucose or
- 5% glucose solution in 0.9% saline at a rate of 150-200 ml per hour.
- We should either use adequate devices for warming infusion fluids or place the bottle with infusion fluid in a temperature-controlled bath.
- **Ringer's solution is not recommended** for infusion in such cases because lactate metabolism decreases in the hypothermic liver.

Attention: Hypothermic patients must not receive fluids that had not been warmed.

When hypothermia occurs due to prolonged stay in cold water, the more tragic are the effects of premature termination of rewarming and resuscitation. Such victims are often considered drowned too early and their resuscitation is not always properly conducted till the very end.
Hypothermic patients should be transported to hospital as fast as possible.

Hospital management

Following the delivery of a hypothermic patient to hospital, further management should be conducted according to a proper scheme. (Table 3) Effectiveness of treatment increases in proportion to the progress of knowledge on pathophysiology of hypothermia. Mortality among victims of hypothermia may be low, especially in case of young people.

1. Mild hypothermia (body temperature: from 34 to < 36˚C)

Mildly hypothermic patients reveal good prognosis in terms of survival as long as they were rewarmed quickly. External rewarming is sufficient: using heat from an electric blanket or other sources.

In conscious patients we can use methods of external passive rewarming by protecting them from heat loss using blankets or a sleeping bag, as well as active rewarming with the use of an electric blanket, hot water bottles, warm bath or heat-releasing packs (chemical reaction) placed along the arms, neck, chest, abdomen and groin. However, it should be noted that it is not possible to monitor and record ECG during a bath.

Table 3: Hypothermia * - hospital management scheme

	INTERVENTION	PRECAUTIONS
37,5˚C	Normal body temperature measured in the oral cavity	
	Mild hypothermia: body temperature: 34 to <36ºC—Protect from further effects of cold.	
36˚C	Keep moving but without exertion. Warm bath	Do not massage cold limbs! Do not administer drinks containing alcohol or caffeine
35˚C	Administer hot, sweet, high-calorie drinks. Recommend staying in a warm room for a few hours. Protect from further heat loss.	
	DIAGNOSE COEXISENT INJURIES—OBSERVE THE PATIENT FOR 48 HOURS	
	Moderate hypothermia—body temperature: 30˚C to 33.9˚C — requires hospital treatment	
	Protect from arrhythmias	Do not perform excessive movements.
34˚C	Rewarm only the chest and trunk.	Do not rewarm externally aside from the chest and trunk
33˚C	Administer hot, sweet drinks. Administer oxygen or air humidified and warmed up to 42-46ºC through a face mask	Do not ad minister cold oxygen or air.
32˚C	Give intravenous fluids warmed up to 40-43ºC: 5% glucose in 0.9% saline,. or 5% glucose. Monitor: pulse, respiratory rate and ECG. Do not ad minister any oral fluids other than gel glucose	Do not ad minister cold drinks. Do not overload the circulation with intravenous fluids
31˚C	Monitor breathing and body position. Change the body position every 2 hours to prevent decubitus ulcers.	Do not give food or drinks.
	Severe hypothermia: body temperature below 30ºC requires hospital treatment	
	If necessary intubate the patient. If necessary defibrillate.	Intubation may cause ventricular fibrillation.
30˚C	Maintain the patency of the airways and conduct assisted respiration with humidified air or 50% oxygen warmed up to 42-46ºC through a mask at a rate of 12-15 breaths / minute.	Do not administer i.v. drugs if body temperature remains below 30ºC., e.g. lignocaine, propranolol.

	INTERVENTION	PRECAUTIONS
29˚C	Cardiac massage: 80-100 chest compressions / minute. Peritoneal dialysis with warm fluid and/or warming blood with extracorporeal circulation	Do not defibrillate when body temperature remains below 30ºC.
>28˚C 27˚C	Patient does not exhibit any signs of life.	Maintain resuscitation: until core temperature reaches 35ºC - until patient is declared dead!
Severe hypothermia: body temperature below 20ºC—requires hospital treatment		
>20˚C	Patient does not exhibit any signs of life	Do not quit CPR – until patient is declared dead!

* HYPOTHERMIA – body temperature below 36.0ºC (thermometer for measuring body temperatures below 36.0ºC)

2. Moderate hypothermia (body temperature: from 30ºC to 33.9˚C)

Treatment should involve all basic recommendations mentioned above except for active external rewarming. Additionally, the following should be performed if necessary:

- cardiopulmonary resuscitation – in any case of asystole diagnosed based on auscultation for 45 seconds or an ECG,
- heart rate and respiratory rate should be monitored for a long period of time.

One should remember that:

- abolished light reflex response, attenuated reflexes, inability to determine blood pressure, lack of reaction to pain – are not basis for declaring a hypothermic patient dead,
- following general rules for declaring death in a hypothermic patient may delay initiation of proper therapeutic life-saving interventions,
- rewarming does not equal reversing the process of hypothermia, especially in patients who pass from moderate to deep hypothermia over a long period of time.

One should also remember that external whole body rewarming is a very risky intervention; it may lead to dilatation of peripheral vasculature and hypotension as well as relocation of cold blood returning to the heart. It leads to further decrease in temperature of internal organs. It contains large amounts of lactic acid, lowers blood pH and may contribute to development of ventricular fibrillation.
The key to success in rescuing such patients is **passive rewarming**, which stabilizes temperature through protection against further heat loss.

The most effective treatment in this group of patients is a **method of active core rewarming** through direct transmission of heat to the inside of the body: through administration of warmed, humidified oxygen or air for inhalation and infusion of warm fluids into central veins.

After proper circulation and breathing is restored at hospital, patients may be additionally rewarmed externally through direct transmission of heat onto the chest and abdomen, but not the limbs, under constant monitoring of core body temperature.

3. Severe hypothermia (body temperature below 30 ˚C)

Initiation of out-of-the-hospital treatment in case of patients suffering from severe hypothermia requires supplying emergency vehicles with appropriate equipment and trained personnel. Heart rhythm monitoring should be started at the site of the accident although it should not delay transport to hospital.

Endotracheal tube should be placed in order to ensure airway patency and enable ventillation with warm, humidified oxygen or air. Careful intubation may protect the patient from ventricular fibrillation. Defibrillation should be carried out if ventricular fibrillation appears, all the while remembering that a heart cooled down to a temperature below 30 ºC does not always respond to electrical stimuli and administered medications. Defibrillation may prove effective only after rewarming the heart above this critical temperature.

During treatment of hypothermia we should:

- monitor body temperature,
- monitor results of laboratory tests: blood gasses, potassium and glucose levels, base excess,

correcting them when necessary

Attention:

- core temperature may be lower than measured skin temperature and we should make sure it does not drop any further,
- complications that may occur during rewarming: arrhythmias or pulmonary edema as a result of fluid overload.

Treating a patient in severe hypothermia with asystole requires rapid, direct actions and core reheating of internal organs.
Any injuries in such patients may be treated in a similar fashion as in patients with hypothermia up to 32 °C and results are often better than in patients with normal body temperature.
Measurement of esophageal core body temperature, as the closest to the temperature of the heart, is more accurate than that taken on the tympanic membrane or in the rectum.

Laboratory tests to be done at hospital.

If possible, the following tests should be performed immediately after arrival in the hospital:

- blood gass,
- complete blood count,
- prothrombin time,
- serum levels of: glucose, electrolytes, urea, creatinine, amylase, liver function tests, ECG, chest x-ray and urinalysis.

Methods of rapid core rewarming at hospital:

- **ventilation with humidified oxygen/air warmed up** to 42-46°C,
- **central infusion of fluids** warmed up to 40-43 °C at a rate of 150-200 ml/hour while watching for the signs of fluid overload,
- **peritoneal dialysis** with 2 liters of potassium-free fluid warmed up to 43°C. Peritoneal lavage is a less complicated intervention. It may be carried out in severe hypothermia resulting in rapid warming of internal organs.
- **hemodialysis**, although slower and less effective, is also very practical due to relatively small invasiveness from a surgical point of view,
- **extracorporeal circulation** used in treatment of severely hypothermic patients – if available, it allows for quick and controlled rewarming.
- rewarming through a gastric tube – used in many European hospitals when extracorporeal circulation is not available,
- **pleural cavity lavage** may be very helpful and allows for rewarming at a rate of 2.5 °C per hour, but is associated with potential complications and should be performed only when other means are not available.

These methods allow for quick core rewarming in victims of hypothermia.

Extracorporeal circulation is the method of choice in severe hypothermia but available only in large, well-equipped Medical Centers.

Terminating life-saving efforts

Hypothermic patients not exhibiting any signs of life should be treated vigorously because otherwise they will not survive without central nervous system deficits. Interventions aimed at increasing body temperature above 35 °C can be terminated if a patient warmed up to this temperature is in asystole and remains unresponsive to administered treatment. Doctor's decision regarding termination of resuscitation should be always individualized and made separately by taking all circumstances into consideration.

Effective treatment of hypothermia requires that every Emergency Facility and Emergency Department should be staffed with well-trained personnel experienced in providing medical aid and methods of resuscitation of hypothermic patients. Severe hypothermia may accompany every disease. Therefore, doctors must know its symptoms and methods of treatment.

Conclusions

- Introducing a hypothermia treatment algorithm should facilitate understanding of the problem and improve the effects of rewarming and therapy.
- The following methods should be applied in treatment of hypothermic patients: cardiopulmonary resuscitation, temperature stabilization through ventillation with warm, humidified oxygen/air and infusion of warm fluids into central veins.
- Rewarming and treatment of a hypothermic patient at hospital may require intubation, placing a central line, peritoneal lavage with warm fluids or application of extracorporeal circulation.

- During the post-resuscitation period, the

patient requires careful observation at hospital due to the possibility of respiratory, hematologic and renal complications.

- Examinations of heart temperature in hypothermic patients undergoing rewarming procedures revealed that effectiveness of rewarming as well as increase in temperature are greater if the patient is ventilated with humidified air warmed to 44 °C and receives infusions of warm fluids.
- One should remember that using Ringer's solution may be dangerous for the hypothermic patient due to decreased lactate metabolism in the hypothermic liver.

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