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Review Article

Protocol Targeted Temperature Management

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Abstract

Therapeutic hypothermia (TH), as the main method of targeted temperature management (TTM), consists of the use of neurovegetative blockades and general cooling of the body. TTM has been widely used in clinical practice since the mid-twentieth century thanks to the work of the scientificschool of Bigelow, Rozomoff, Safar, and their followers.

The use of the TTM method significantly improved the effectiveness of shock therapy,significantly increasing the period of reversible changes in the central nervous system (CNS)during total ischemia and reducing the neurological consequences of neurotrauma. This led to itswidespread use in intensive care, cardio- and neurosurgery, and traumatic brain injury treatment. The large volume of experimental and clinical studies performed allows us to reasonably considerTTM as a neuroprotection method that has a positive effect on most of the key mechanisms ofsecondary neuron damage.

Thus, the depression of metabolism in cells due to hypothermia is considered an important component of the neuroprotective effect of TTM. Reducing the need for oxygen and ATP helps toreduce the reactions of neurons to ischemia and lengthen the period of their life in hypoperfusion.Restriction of local inflammation in ACA and neurotrauma during hypothermia is accompanied bya decrease in leukocyte migration and infiltration of brain tissue by them, decreased edema, anddecreased ICP. TTM reduces the amount of damage to the nervous tissue and neuronal death.

In this article, we propose our own TTM protocol based on our own and international experience of conducting hypothermia.

Keywords: Therapeutic Hypothermia (TH); Targeted Temperature Management (TTM); Stroke; CPR

Abbreviations

TH: Therapeutic Hypothermia; TTH: Targeted Temperature Management; CPR: Cardio Pulmonary Resuscitation; CNS: Central Nervous System; BSAS: Bedside Tremor Rating Scale

Introduction

Therapeutic hypothermia (TH), as the main method of targeted temperature management (TTM), consists of the use of neurovegetative blockades and general cooling of the body. TTM has been widely used in clinical practice since the mid-twentieth century thanks to the work of the scientific school of Bigelow, Rozomoff, Safar, and their followers [1]. Considering the rich Russian experience of using TH in emergency conditions in the 1950s and 1980s (the work of the school of academician V.A. Negovsky, Meshalkin E.N., Bunyatyan A.A., Moroz V. V., Ugryumova V.M.), as well as the well-known mechanisms for maintaining the thermal balance of the brain, it seems promising to use cooling methods as a tool for correcting disorders of cerebral and general temperature balance.

The use of the TTM method significantly improved the effectiveness of shock therapy, significantly increasing the period of reversible changes in the central nervous system (CNS) during total ischemia and reducing the neurological consequences of neurotrauma, which led to its widespread use in intensive care, cardio- and neurosurgery, and traumatic brain injury [3].

Mechanisms of effects of TTM in CNS damage

Immediately after the development of acute cerebrovascular accident (ACA) or neurotrauma, a primary lesion forms rapidly, leading to hypoxia and secondary damage to neurons [4]. Hypoxia and lack of brain nutrients quickly lead to disorders of transmembrane potential, synaptic transmission, axonal transport, and action potential [5].

Oxidative stress and local inflammation [6] begin to manifest themselves in the first 2-3 hours of ACA onset, reaching a maximum after 12-36 hours, providing the basis for the development of long-term consequences of stroke, which are mainly formed within 2-3 days. This process is also facilitated by the activation of apoptotic neuronal death [7,8].

Restoration of adequate perfusion and effective neuroprotection aimed at preserving neurons are the main tasks of stroke therapy starting from the first hours of the disease.

TTM – neuroprotection method

The large volume of experimental and clinical studies performed allows us to reasonably consider TTM as a neuroprotection method that has a positive effect on most of the key mechanisms of secondary neuron damage.

Thus, the depression of metabolism in cells due to hypothermia is considered an important component of the neuroprotective effect of TTM [9]. By reducing the need for oxygen and ATP, it helps to reduce the reactions of neurons to ischemia and lengthen the period of their life in hypoperfusion. Restriction of local inflammation in ACA and neurotrauma during hypothermia [10] is accompanied by a decrease in leukocyte migration and infiltration of brain tissue by them [10], reduced edema, and decreased ICP [11]. As a result, TTM reduces the amount of damage to the nervous tissue and neuronal death [12].

Indications

- After the restoration of spontaneous circulation (CPR)
- For the treatment of patients in a comatose state after cardiac arrest outside the hospital with a restored rhythm of ventricular tachycardia or ventricular fibrillation;
- For the treatment of patients in a comatose state after cardiac arrest in a hospital, and patients with a restored rhythm of ventricular tachycardia or ventricular fibrillation.
- Traumatic brain injury
- Cerebral infarction
- Intracerebral hematoma
- Hypoxia of the brain

Contraindications

- Actively continuing bleeding
- The use of fibrinolytics **within** 2 hours before the start of the session
- Planned surgical interventions
- Oncological diseases during treatment and in the terminal stage

General preparatory stage

Before starting targeted temperature control, the patient should be hemodynamically stable, intubated, and transferred to artificial ventilation with optimal parameters of oxygenation and ventilation. Minor vasopressor support is allowed.

In addition, it is necessary to assess the initial clinical status and provide hemodynamic monitoring. Ensure that the following data is obtained and procedures are performed before the start of the TTM:

- Basic tests, including blood gases and acid-base state of blood, cardiac, liver enzymes, electrolytes, coagulogram, markers of inflammation, kidney function, troponin, and lactate, have been evaluated.
- Continuous ECG monitoring is provided.
- Endotracheal intubation and mechanical ventilation.
- Pulse oximetry.

- Non-invasive blood pressure monitoring.
- Arterial catheter if invasive blood pressure monitoring is necessary.
- Central venous catheter.
- Large-caliber peripheral catheter.
- Continuous temperature measurement (esophageal, rectal, or bladder probe).
- Foley catheter.
- The cooling equipment is working properly and ready to work (varies depending on the hospital).
- The heating system is serviceable and ready for operation (if necessary).
- Optional BIS-monitoring.
- Optional TOF monitoring.

TTM methods

Traditional cooling method

The traditional method of cooling is to use infusions of cold saline solution and ice packs. It is the simplest and most cost-effective method. The advantage of this method is that it is widespread, easy to use, can be initiated by paramedics in the field, and is considered a safe method of induction of hypothermia. It can also be used as an adjunct to more modern cooling methods to increase the cooling rate. The disadvantage of using the traditional method is that it is very time- consuming, often leads to a temperature below the target, and is inefficient in maintaining the target temperature. The patient's cooling rate is 0.2-0.5°C/hour.

Surface cooling systems

Surface cooling systems use blankets or applicators (including helmets) wrapped around the patient, in which cold air or liquid circulates. These devices are less labor-intensive and easy to use; most of them are equipped with automatic feedback mechanisms that change the temperature of water or air to maintain a given target temperature.

The disadvantages include a rare risk of frostbite and skin irritation (urticaria and redness), as well as the risk of exceeding the target temperature at the induction stage. Patient cooling rate: water – 1.3-2 °C/hour; gel – 1-1.5 °C/hour. ΔT °C (water) when held - 0.58 ± 0.47 °C; ΔT °C (air) when held - 0.67 ± 0.36 °C; ΔT °C (gel) when held - 0.45 ± 0.42 °C.

Invasive cooling systems

Currently, invasive cooling systems are represented by systems of intravascular catheters installed in the central vein, through which cold saline solution circulates. They are considered the most reliable at all three stages of hypothermia treatment.

The disadvantages of intravascular cooling devices are that they require an invasive procedure, there is a possibility of thrombosis and infection associated with the catheter, and they are relatively expensive. Other core cooling systems, such as the use of peritoneal lavage and extracorporeal circulation devices, have not yet become widespread. Patient cooling rate: 2.0 - 4.5°C/hour (depending on catheter size and settings). ΔT °C when held - 0.24 ± 0.14 °C.

Temperature measurement

The use of TTM requires constant monitoring of body temperature. This is vital to achieve an accurate target temperature, prevent hypothermia, estimate temperature fluctuations during the maintenance phase, and ensure a stable, controlled temperature rise during the warming phase. The ideal place to measure body temperature is the place that provides accurate measurement in real time. Currently, the gold standard is the measurement of blood temperature using a pulmonary artery catheter. The most frequently used monitoring sites (bladder, rectum, esophagus, and eardrum) demonstrate a time delay between the recorded temperature and the measured body temperature, especially at the induction stage when large temperature changes occur in a short time. This may result in exceeding the target temperature during induction.

Esophageal temperature is the fastest and most accurate reflection of the gold standard, with an average delay time of 5 minutes (range from 3 to 10 minutes). The ideal depth of insertion of the probe is from 32 to 38 cm; this minimizes the likelihood of displacement down into the stomach. The disadvantage of this method is the possibility of intervention in specific therapeutic and diagnostic procedures (transesophageal echocardiography, feeding tubes, etc.).

The bladder temperature has an average lag time of 20 minutes compared to the gold standard. Inserting a probe into the bladder is relatively convenient and easy since it is combined with the introduction of a urethral catheter - a procedure that is often performed in any case. The accuracy of measuring bladder temperature depends on the rate of diuresis, which may be low in patients after cardiac arrest, making this method of measuring temperature less reliable.

Rectal temperature has an average delay time of 15 minutes. The introduction of a rectal probe is a quick and simple procedure; however, there is a high frequency of probe displacement.

Peripheral areas are completely inaccurate and should never be used for guidance in TTM.

Technique of the procedure

The process of purposeful temperature control can be divided into three phases: the induction phase, the maintenance phase, and the reheating phase.

The goal is to reach a body temperature of 32-34 °C as soon as possible, maintain this temperature for 24-48 hours, and then rewarm at a controlled rate of 0.5-1 °C/hour.

Induction phase

The induction of hypothermia is a process in which the target body temperature of 32-34 °C is reached as quickly as possible. This can be achieved by using several different external and internal cooling mechanisms. The induction of hypothermia is carried out only in the conditions of intensive care and intensive care in a hospital. To compensate for polyuria, hypernatremia, and hypokalemia, infusion therapy with 10% glucose solutions of 60-100 ml/kg/day of the patient's weight and constant infusion of 4% potassium chloride at 2-4 ml/kg/day is recommended.

To ensure adequate sedation and muscle relaxation, it is recommended to use the following solutions: propofol, sodium thiopental 2%, morphine 1%, rocuronium bromide – under the control of BIS and TOF monitoring. The occurrence of muscle tremors indicates insufficient muscle relaxation. A rise in pressure of more than 10% indicates insufficient sedation.

To meet nutritional needs, it is recommended to use parenteral nutrition, and enteral administration is limited to water only.

Complications

Muscle tremor, hypernatremia, hyperkalemia, hypokalemia, arterial hypertension, arterial hypotension, tachycardia, bradycardia.

Ensuring patient safety during induction:

- Monitoring of cerebral function (assessment of the level of consciousness/sedation, BIS monitoring)
- Monitoring of hemodynamic parameters (non-invasive/ invasive blood pressure measurement)
- Monitoring of respiratory function (respiratory mechanics and arterial blood gas composition)
- Monitoring of gastrointestinal function (control of discharge by nasogastric probe)
- Monitoring of kidney function
- Control of water-electrolyte balance (hyperkalemia, hypokalemia, hypernatremia)
- Control of glycemia (hypoglycemia, hyperglycemia)
- Control of blood clotting ability (coagulopathy)
- Infectious safety
- Epidemiological control

The phase of maintaining the set temperature

The duration of the phase is not less than 24 hours, not more than 48 hours. In order to compensate for polyuria, hypernatremia and hypokalemia, infusion therapy with glucose solutions of 10% 60-100 ml/kg/day of the patient's weight, constant infusion of potassium chloride 4% - 2-4 ml / kg / day is recommended.

At this phase, it is permissible to stop the introduction of muscle relaxants. If tremors occur, it is necessary to resume the action of the neuromuscular blocker. The target value of average blood pressure (SAD) should be maintained in the range of 80-100 mm Hg. In the event of non-stop life- threatening arrhythmia, with the development of unstable hemodynamic parameters or bleeding, active cooling should be stopped and the patient warmed up again. Arrhythmias (most often bradycardia) may

occur due to hypothermia. A heart rate of less than 40 beats per minute is common and is not a cause for concern in the absence of other evidence of hemodynamic instability. During cooling, an electrocardiographic (ECG) Osborne wave or a camel wave may be present in the V3 – V6 leads between the QRS and the ST segment [13].

Complications

Muscle tremor, hypernatremia, hyperkalemia, hypocalemia, arterial hypertension, arterial hypotension, tachycardia, bradycardia.

Ensuring safety during therapy:

- Monitoring of cerebral function (assessment of the level of consciousness/sedation, BIS- monitoring)
- Monitoring of hemodynamic parameters (non-invasive/ invasive method of measuring blood pressure)
- Monitoring of respiratory function (respiratory mechanics and gas composition of arterial blood)
- Monitoring of gastrointestinal function (control of discharge by nasogastric probe)
- Monitoring of kidney function (cold diuresis)
- Control of water-electrolyte balance (hyperkalemia, hypokalemia)
- Control of glycemia (hypoglycemia, hyperglycemia)
- Control of blood clotting ability (coagulopathy, hypocoagulation)
- Infectious safety
- Epidemiological control.

The warming phase

At this stage, the body temperature gradually rises by 0.2-0.5 °C per hour until it exceeds 36.6 °C.A slower rate of rewarming is associated with fewer complications, and rapid warming can negate the benefits of therapeutic hypothermia. When the temperature reaches 36.6 °C, you can stop using cooling devices and medicines used to combat shivering. The reheating phase begins24-48 hours after induction and can last up to 12-16 hours.

Ensuring safety during therapy:

- Control of cerebral function (assessment of the level of consciousness/sedation, BIS monitoring)
- Control of hemodynamic parameters (non-invasive/invasive method of measuring blood pressure)
- Control of respiratory function (respiratory mechanics and gas composition of arterial blood)
- Control of gastrointestinal function (control of discharge by nasogastric probe)
- Control of kidney function
- Control of water-electrolyte balance (hyperkalemia, hypokalemia)
- Control of glycemia (hypoglycemia, hyperglycemia)
- Control of blood clotting ability (coagulopathy, hypocoagulation)
- Ensuring infectious safety
- Epidemiological control

Monitoring, prevention, and treatment of possible side effects:

- "Rebound" syndrome ("rebound effect") – an increase in ICP
- ICP monitoring
- BRAID control
- Changes in hemodynamic parameters:
- The target value of SAD is more than 80 mmHg
- Norepinephrine, starting from 0.01 mcg/kg/min and titrating to SAD values of more than 80 mmHg.

Complications

Purposeful temperature maintenance is associated with numerous physiological changes, some of which can lead to complications during treatment. Staff involved in the care of patients undergoing therapeutic hypothermia should know and anticipate these potential complications, as taking preventive measures, early recognition, and treatment of complications improve survival.

Cardiovascular complications

Most of the TTM complications affect the cardiovascular system since 80% of patients have a history of heart disease without

hospital cardiac arrest. A decrease in body temperature activates certain thermoregulatory mechanisms, including peripheral vasoconstriction caused by sympathetic stimulation and increased production of catecholamines, which can aggravate already existing cardiac dysfunction by increasing the myocardial oxygen demand. Hypothermia can also cause coronary vasoconstriction, increasing the risk of myocardial infarction. Changes in hemodynamic parameters include:

- A decrease in cardiac output by 25%
- An increase in blood pressure
- An increase in peripheral vascular resistance
- Sinus bradycardia.

Fortunately, serious arrhythmias rarely occur at the temperature used in TTM (from 32 to 34 °C). The risk of arrhythmias increases with a decrease in body temperature below 30 °C. Such low temperatures are rarely intentionally used for therapeutic hypothermia, but due to the time delay between the resulting temperature on the device and the actual body temperature when using areas other than the blood itself, exceeding the target temperature is not uncommon.

Renal complications

Cold-induced diuresis poses a significant problem for patients with hypothermia. Cold diuresis is a diuretic reaction caused by a combination of factors, including increased venous return due to vasoconstriction, elevated levels of atrial natriuretic peptide (ANP), decreased levels of antidiuretic hormone (ADH), and tubular dysfunction. If left untreated, this condition can lead to hypovolemia, electrolyte imbalances, and hemoconcentration.

Electrolyte disturbances

Hypothermia-induced diuresis, along with tubular dysfunction and intracellular ion shifts, leads to a decrease in the serum concentration of several electrolytes, including magnesium, potassium, and phosphates. Regular measurement and correction of electrolyte levels, if necessary, are essential. Studies have demonstrated that during the first 6 hours of cooling, the levels of Mg decreased from 0.98 ± 0.15 to 0.58 ± 0.13 mmol/L (mean value ± standard deviation; $p < 0.01$), phosphate levels decreased from 1.09 ± 0.19 to 0.51 ± 0.18 mmol/l ($p < 0.01$), Ca levels decreased from 2.13 ± 0.25 to 1.94 ± 0.14 mmol/l ($p < 0.01$), and K levels decreased from 4.2 ± 0.59 to 3.6 ± 0.7 mmol/l ($p < 0.01$) [14]. Electrolyte levels do not change during normothermia. Hypomagnesemia can cause cerebral and coronary vasoconstriction and exacerbate reperfusion injury to the brain. Hypokalemia and hypophosphatemia can cause life-threatening tachyarrhythmias and weakness of the respiratory muscles, increasing the risk of respiratory infections and the inability to wean from mechanical ventilation. Regular measurement of serum electrolytes and their correction, if necessary, are the most important preventive measures.

The reheating phase may also be associated with electrolyte disturbances. Hyperkalemia often occurs in this phase due to the release of intracellular potassium and can lead to cardiac arrhythmias. Warming the patient at a slow and controlled pace can prevent this complication by giving the kidneys more time to remove excess potassium [15].

Immune disorders

Hypothermia causes a number of changes in immune function. However, they can also increase the risk of infectious complications. Hypothermia suppresses various inflammatory reactions. It disrupts the secretion of pro-inflammatory cytokines and suppresses leukocyte migration and phagocytosis [15]. Hyperglycemia and peripheral vasoconstriction, which often occur with hypothermia, also contribute to an increased risk of infections. The risk of infectious complications increases with prolonged hypothermia. Nevertheless, a high level of vigilance should be maintained and certain measures should be taken in all patients with therapeutic hypothermia for the prevention and early detection of infections. These include regular microbiological monitoring, timely catheter replacement, examination of wounds and catheter insertion sites, as well as the avoidance of hyperglycemia.

Metabolic disorders

Hypothermia causes a linear decrease in metabolic rate by 5-7% per 1 °C decrease in body temperature. The left shift of the hemoglobin dissociation curve to oxygen reduces the availability of oxygen to tissues and may contribute to the development of metabolic acidosis. Oxygen consumption and CO_2 production are reduced equally. If the settings of the ventilator are not

adjusted properly, a decrease in CO_2 production can contribute to the development of respiratory alkalosis and hypocapnia. This leads to cerebral vasoconstriction, increased cerebral vascular resistance and decreased cerebral blood flow. Pharmacokinetic and pharmacodynamic changes in drug metabolism may occur in patients receiving therapeutic hypothermia. During the course of treatment, these patients receive a variety of medications, including muscle relaxants, anticonvulsants, sedatives and cardiovascular agents. Due to changes in metabolism, unforeseen drug toxicity may occur, especially since many of these drugs have a narrow therapeutic window. The mechanisms involved in these changes depend on the specific drug and may occur at one or more different phases of metabolism, reaction or elimination of the drug. Clinical studies evaluating the effect of hypothermia on the metabolism of specific drugs have shown that for many widely used drugs, such as propofol, vecuronium, rocuronium, midazolam and phenytoin, there was an increase in serum concentration, a decrease in creatinine clearance rate and an increase in duration of action [16]. Metabolism gradually returned to its initial level during the warming phase. This suggests that the doses of medications should be reduced to prevent toxicity.

Trembling

Trembling is a thermoregulatory reaction to hypothermia, which occurs when the body temperature drops below 36.5 ° C. Shivering produces heat through rhythmic contraction and relaxation of skeletal muscles, which increases oxygen consumption, energy and induction time. These changes counteract many beneficial effects of therapeutic hypothermia, therefore, in order to maximize the effect of hypothermia, it is necessary to suppress trembling. This can be achieved through various pharmacological and non-pharmacological interventions.

Complications in the warming phase

Warming is associated with several complications, the most important of which are electrolyte disturbances and hemodynamic instability. The intracellular shift of electrolytes that occurs during cooling is reversed in this phase, and the resulting increase in extracellular ions, especially potassium, can lead to fatal cardiac arrhythmias. To prevent hyperkalemia, warming should occur at a slow and controlled pace, which allows the kidneys to more effectively remove excess potassium. In patients with oliguria, renal replacement therapy should be initiated before re-warming. In addition, all patients should stop taking potassium-containing liquids before warming up. Hypothermia causes peripheral vasodilation and redistribution of blood, which leads to hypotension and, accordingly, a decrease in oxygen delivery to tissues. This can be avoided if you increase the volume of blood with saline solution 4-8 hours before warming up. It is very important to carefully monitor hemodynamic parameters at this stage, regularly assessing blood pressure, urine volume and serum lactate.

Improving the effectiveness of the team of medical workers

Effective use of the TTM requires an interprofessional team of medical professionals working in a coordinated and effective manner. It all starts with an emergency medical team performing timely and effective cardiopulmonary resuscitation, then doctors and nurses of the emergency room (shock room) initiating the TTM protocol adopted in the institution, and finally, teams in the intensive care unit who continue the TTM protocol and cope with any complications that may occur. Other specialists may be involved in the care of such patients, for example, cardiologists for PCI or neurologists for neurological prognosis. It has been proven that early initiation of TTM is associated with improved neurological outcomes. There are many reasons why the start of the TTM may be delayed. These include ignorance of the TTM protocol of the institution, transportation to institutions that are not familiar with the provision of care after cardiac arrest, unclear etiology of cardiac arrest, and others. Improvement of outcomes in patients undergoing TTM after cardiac arrest can be achieved by improving communication between medical professionals, transferring patients after cardiac arrest to centers with experience in providing care after cardiac arrest, as well as by constantly updating and familiarizing the institution with the TTM protocol.

Nursing and monitoring of TTM teams

Induced hypothermia is associated with several physiological disorders, and frequent monitoring is necessary for early detection and treatment of complications. The following is a brief description of the main aspects of patient care.

Trembling

The Bedside Tremor Rating Scale (BSAS) is a rating system that allows you to quantify tremors. It uses a four-point scale and can

be easily performed at the patient's bedside and used to correct therapy [17].

Medications can suppress tremors through several different mechanisms involving different types of receptors, which leads to a decrease in the tremor threshold, peripheral vasodilation and/or neuromuscular blockade. The most commonly used drugs are opioids, short-acting benzodiazepines and muscle relaxants.

The optimal approach to quiver suppression has not been established. Most likely, there is no approach that would be ideal for all patients, since the threshold and severity of tremors, the response to different types of therapy, as well as variations in the pharmacodynamics and pharmacokinetics of these drugs are different in different patients. These variations are due to differences in age, gender, body surface area, baseline level of neurological damage, and other factors.

Analgesia and sedation

The patient should receive adequate analgesia and sedation at all stages of the therapeutic hypothermia protocol. Currently, there is no evidence in favor of one or another sedative/analgesic during the TTM. It should be noted that hypothermia alters the pharmacokinetic properties of these drugs, and it may be necessary to reduce the dose due to a decrease in creatinine clearance.

Blood pressure

Hypotension leads to a decrease in cerebral blood flow and subsequent ischemia. Adequate blood pressure control is necessary during therapeutic hypothermia and may require the use of vasopressor support. Current data indicate the need to maintain systolic blood pressure >80 mmHg or average blood pressure >65 mmHg.

Glucose control

Hyperglycemia may be associated with poor neurological outcomes and increased mortality Hypothermia increases the risk of impaired glucose levels due to changes in insulin sensitivity. It is necessary to monitor the blood glucose level. However, aggressive treatment is not recommended, and these recommendations do not specify the target blood glucose level.

Oxygenation

Optimization of oxygenation and ventilation improves the outcome. Blood oxygen saturation should be maintained at a level above 94%, and $PaCO_2$ – from 35 to 45 mmHg. It has been shown that hyperoxia correlates with increased mortality compared with normoxia and hypoxia [18]. Whenever possible, FiO_2 should be titrated to the minimum value necessary to maintain saturation >94%.

Electrolyte disturbances

Although therapeutic hypothermia is associated with numerous electrolyte disorders, special attention should be paid to potassium. At the stages of the induction phase and the phase of maintaining the set temperature, hypokalemia may occur due to the sequestration of potassium in cells. During these phases, potassium reserves should be replenished as needed. With an increase in body temperature during warming, the potassium shift occurs in the opposite direction, and hyperkalemia may develop. During the warming phase, it is recommended to stop replenishing potassium reserves.

Conclusion

Despite the complications that arise during therapeutic hypothermia, it has a number of advantages. This protocol developed by us allows us to develop an optimal strategy for managing body temperature with minimal risks for the patient.

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