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REVIEW ARTICLE

Perioperative temperature management in adult anesthesia

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Abstract

Body temperature management is of importance to be controlled in surgery, because there are a considerable amount of effects caused by uncontrolled body temperature during operations, such as decreased heart rate, breathing frequency and blood pressure, cyanotic skin, and even decreased consciousness. The body already has an auto-mechanism of reducing the risk of decreased temperature during surgery such as skin vasoconstriction, changes in behavior, shivering and non-shivering thermogenesis. Many factors can influence changes in body temperature thermoregulation in the operating room such as operating room temperature, area of surgery wound, fluid, age, anesthesia, and the duration of the operation. Thus, perioperative temperature management needs to be understood.

Keywords: *Body temperature management, shivering, non-shivering, thermoregulation*

Introduction

Body temperature varies at any time and is maintained within a normal range of between 36.5°C to 37.5°C at ambient temperature. Body temperature is controlled by the thermoregulatory center in the hypothalamus by balancing excess heat production with loss. The anterior hypothalamus regulates heat loss, whereas the posterior hypothalamus regulates heat production. If the hypothalamus detects a decrease in body temperature below the regulatory point, the body will start the mechanism of heat conversion by means of vasoconstriction to reduce blood flow to the skin and extremities.[1]

Hypothermia is a post-anesthesia complication that is often found in the recovery room, both post-general and regional anesthesia. One in three patients will experience hypothermia during surgery if no intervention is made. About 30% to 40% of post-anesthesia patients are found to have hypothermia when they arrive at the recovery room. Hypothermia is a state of body temperature below 36°C. In hypothermia, heat production is not enough to provide energy for the body to function. In the operating room, cold room air, fluid, and exposure to patients is a major cause of hypothermia.[2,3]

Anesthesia inhibits central thermoregulation of normal core body temperature and shivering. Inhaled agents cause vasodilation thereby increasing heat loss. In addition, this agent also affects the hypothalamus and the role of thermoregulation. Regional anesthesia results in sympathetic blocks, muscle relaxation, and blocking sensory thermoreceptors, preventing the onset of an appropriate response. Spinal and epidural anesthesia cause vasodilation resulting in heat redistribution which can lead to hypothermia.[4]

When body temperature drops to 35ºC, patients can shiver, lose their memory, depression and sense disorders. If the body temperature drops below 34.4°C, there can be a decrease in heart rate, breathing frequency, blood pressure, and the skin becomes cyanotic. If hypothermia continues,

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patients can experience cardiac dysrhythmias, and lose consciousness.[5] Because there are so many complications that can result from hypothermia, it is important to know the management of body temperature during surgery. Also in this review article, we want to discuss more about Perioperative Temperature Management in Adult Anesthesia.

Thermoregulatory Physiology

Body temperature varies at any time and is maintained within a normal range of between 36.5°C to 37.5°C at ambient temperature. Body temperature is controlled by the thermoregulation center in the hypothalamus by balancing excess heat production with heat loss. The production of heat in the body depends on the metabolic rate that occurs in body tissues. Several mechanisms play a role in heat production.[6]

Shivering thermogenesis (Shivering thermogenesis) is involuntary muscle activity which is the body's effort to maintain body temperature during cold exposure. Shivering can increase metabolic heat by 2 to 3 times, but is relatively small with the heat produced during exercise. Non-shivering thermogenesis (non-shivering thermogenesis). This happens to newborns. The source of this heat formation energy is brown fat. In newborns, brown fat is found in the scapula, axilla and kidney area. Brown fat is different from ordinary fat, smaller in size, contains more mitochondria, is supplied with sympathetic nerves, and is rich in blood supply. Stimulation of sympathetic nerves by cold temperatures will increase the concentration of cAMP in brown fat cells, which then activates oxidative phosphorylation in mitochondria through lipolysis. The result of oxidative phosphorylation is the formation of heat which will then be carried quickly by veins which are also abundant in brown fat cells.[6]

Skin vasoconstriction is the most effective effector response to reduce heat loss from skin surface convection and radiation. Changes in behavior such as increased motor activity, trying to find a warmer or use additional warmers, control of the response to behavior towards cold is based on the amount of heat signals received by the skin.[6]

Heat discharges from the body to the environment or vice versa can occur through heat exchange by radiation, conduction, convection, and water evaporation. Radiant heat transfer occurs between two objects with different temperatures that do not come into contact with each other. Conduction is the process of transfer of heat between two surfaces through direct contact. Conduction in the anesthetic process can be prevented by heating intravenous fluids and irrigation solutions that have the potential to reduce body temperature quickly. Patients must also be considered not to be in direct contact with metallic surfaces, because metals have high thermal conductivity and can facilitate heat transfer. Loss of body heat through convection occurs due to the movement of molecules that move, such as air or liquid. Factors that influence evaporation are air humidity, air flow velocity, and minute lung ventilation. Loss through evaporation occurs through three components: sensible water loss through sweating; insensible water loss through the skin, respiratory tract, open surgical wounds; and evaporation from the liquid which is poured into the skin as an antibacterial solution.[7]

Afferent Nerve Pathway

Changes in body temperature are detected by two types of thermoreceptors, namely in the skin (peripheral thermoreceptors) and in the hypothalamus, spinal cord, and others (central thermoreceptors). Central thermoreceptors provide important feedback in maintaining core body temperature when peripheral thermoreceptors provide information. Cold specific receptors release impulses at 25-30°C. This impulse runs on delta type A nerve fibers. The heat receptors emit impulses at 45-50°C and run on type C nerve fibers.[8]

Hypothalamus as a Center for Integration

The afferent thermal information mechanism will be processed by the temperature regulation center in the hypothalamus. The anterior hypothalamus receives integrally afferent thermal information and the posterior hypothalamus controls the descending pathway to the effector. The hypothalamic preoptic region contains sensitive nerves and is sensitive to temperature. The posterior hypothalamus has a role in increasing heat production and reducing heat expenditure. When the ambient temperature is lower than body temperature, the posterior hypothalamus responds by increasing heat production through increased metabolism and skeletal muscle activity in the form of shivering. Heat loss is reduced by vasoconstriction of the skin's blood vessels and reduces sweat production by the sweat glands. While the anterior hypothalamus plays a role in lowering body temperature by releasing heat. When the ambient temperature is higher than the body temperature, the anterior hypothalamus responds by increasing heat expenditure through skin vasodilation and increasing sweat production.[9]

Effector Response

Thermoregulatory responses are characterized by: first, behavioral changes that are quantitatively more effective, secondly, vasomotor responses characterized by vasoconstriction of blood vessels and piloerection in response to cold, and vasodilation and sweating in response to heat, third, shivering and an increase in average metabolic rate. In the conscious state, changes in behavior are more clearly seen than the autonomous mechanism of body temperature regulation. Control of behavioral responses to cold is based on the amount of heat signals received by the skin. Skin vasoconstriction is the most effective effector response to reduce heat loss from skin surface convection and radiation. Non-shivering thermogenesis is defined as an increase in metabolic heat production that is not related to muscle activity. Non-shivering thermogenesis is an important thermoregulator defense in infants. This response is mediated by beta-3 adrenergic receptors that are in brown fat. Shivering (shivering) is involuntary muscle activity that increases metabolic heat by 2 to 3 times. Shivering does not occur in infants and is very ineffective in the first few years. It can be concluded that the regulation of body temperature aims to maintain core body temperature at normal limits by the mechanism as shown below.[8]

Definition of Hypothermia

Body temperature regulation is almost entirely carried out by nerve feedback mechanisms, and almost all of these mechanisms work through the central temperature regulation located in the hypothalamus. This feedback mechanism will work requires a temperature detector, to determine if the body temperature is too hot or cold. Heat will continue to be produced by the body as a byproduct of metabolism and body heat is also continuously discharged into the surrounding environment.[9]

Hypothermia occurs because of exposure to cold environments (low ambient temperatures, cold or wet surfaces. Hypothermia is a clinical state of subnormal body temperatures where heat production is insufficient to provide energy for the body to function. Defined as a state of body temperature below 36°C. Hypothermia also occurs due to a combination of anesthesia and surgery that can cause a malfunctioning of the body's temperature regulation which will cause a decrease in core temperature. Under this temperature, shivering and the autonomic response are unable to compensate completely without the aid of heating.[10,11]

In the operating room, cold room air, fluids and exposure to patients is a major cause of hypothermia. One refrigerated blood unit or 1 liter of crystalloid fluid at room temperature will reduce body temperature by 0.25°C. Heat loss from the skin is as much as 90% of all intraoperative heat loss.[12]

Changes in Perioperative Temperature

The thermoregulation system consists of 3 things namely afferent input, central process, and efferent response. General anesthesia affects all three of the above, while regional anesthesia affects the afferent and efferent. Anesthesia and surgery in cold environments tend to cause this. General anesthesia (inhalation and intravenous drugs) and regional anesthesia (spinal and epidural) extend the threshold range by 4°C, about 20 times normal. Generally, the threshold for sweating and vasodilation increases by about 1°C and the threshold for vasoconstriction and shivering decreases by 3°C. As a result, patients who are anesthetized are relatively poikilothermia with body temperature determined by ambient temperature. Anesthesia inhibits thermoregulation by dose-dependent, inhibits vasoconstriction and shivering by three times and inhibits sweating.[12,13]

Alfentanil and propofol are similar in reducing the threshold for vasoconstriction and sweating. Volatile anesthetics such as isoflurane and desflurane decrease the temperature threshold for nonlinear cold response. Nonshivering thermogenesis does not occur during general anesthesia in adults and children.[14]

Factors associated with hypothermia in the operating room are:

1. Operating room temperature

Exposure to low operating room temperatures can also cause patients to become hypothermic, this occurs due to the propagation between the surface temperature of the skin and the ambient temperature. The operating room temperature is always kept cold (20–24°C) to minimize bacterial growth.[15]

2. The extent of the surgical wound

The incidence of hypothermia can be influenced by the extent of surgery or the type of large surgery that opens the body cavity, for example in orthopedic surgery, thoracic cavity or abdominal surgery is known as a cause of hypothermia because it is associated with long-lasting surgery, extensive incision, and often requires fluid to clean the peritoneal space.[3,16]

3. Liquid

The fluid factor given is one of the things that is associated with the occurrence of hypothermia. Giving intravenous fluids and cold irrigation (according to room temperature) is believed to increase body temperature. Cold intravenous fluids will enter the blood circulation and affect core body temperature (core temperature) so that more cold fluid entering the patient will experience hypothermia.[17]

4. Age

A study from Harahap in 2014, mentioning elderly patients (elderly) included in the extreme age group, is a high risk for hypothermia in the perioperative period. General anesthesia performed in elderly patients can cause a shift in the thermoregulatory threshold to a greater degree compared with younger patients. The elderly age group is a risk factor of the order of 6 (six) as a major cause of perioperative hypothermia. In addition to the elderly, Morgan, Mikhail and Murray in 2013 said pediatric patients, toddlers, and children were not large adult patients. They also have a high risk of postoperative complications. Someone at an elderly age has failed to maintain body temperature, both with and without anesthesia, this is likely due to a decrease in age-related thermoregulatory vasoconstriction.[18]

5. Anesthetic medicine

At the end of anesthesia with thiopental, halothane, or enflurane sometimes cause hypothermia to shiver. That was caused by the effects of anesthetic drugs that cause thermoregulatory disorders.[19]

6. Duration of operation

The duration of surgery and anesthesia has the potential to have a major influence, especially anesthetics with higher concentrations in blood and tissue (especially fat), solubility, longer duration of anesthesia, so these agents must try to achieve balance with these tissues. Induction of anesthesia results in vasodilation which causes the process of loss of body heat to occur continuously. Heat when in fact produced continuously by the body as a result of metabolism. The process of heat production and expenditure is regulated by the body in order to maintain core body temperature in the range of 36-37.5°C.[19] Long duration of surgery, spontaneously causing anesthesia is getting longer too. This will cause the effect of the accumulation of drugs and anesthetic agents in the body more and more as a result of the use of drugs or anesthetic agents in the body. In addition, surgery with a long duration will increase the time the body is exposed to cold temperatures.[2,6]

7. Type of operation

The type of major surgery that opens the body cavity, for example in the thoracic cavity surgery, or the abdomen, will greatly affect the incidence of hypothermia. Abdominal surgery is known as a cause of hypothermia because it is associated with long-lasting surgery, extensive incisions and often requires fluid to clean the peritoneal space. This situation results in heat loss that occurs when the patient's body surface is wet and moist, such as an open abdomen and also the extent of surface exposure to the skin.[18]

Perioperative Temperature Management

Active and passive warming and moisturizing of the airway contributes little to perioperative thermal management, because <10% of heat is lost through ventilation. Each liter of intravenous fluid at air temperature infused into an adult patient, or each blood unit at 4°C will reduce core body temperature by 0.25°C. In view of this, the administration of unheated liquids will greatly reduce body temperature. Warming the temperature of the liquid to near 37°C is useful to prevent hypothermia, especially if large amounts of liquid are infused. Warm intravenous fluids with a temperature of 37ºC conduction into the blood vessels so that it will have a more effective speed of warming through extrinsic. The change in temperature in the blood vessels is detected directly by the thermoreceptors in the hypothalamus. The hypothalamus directly monitors the level of heat in the blood that flows through the brain. Then through the descending tract, it stimulates the vasomotor center so that vasodilation occurs in the arteries which cause blood flow to increase. The high speed of blood flow to the skin causes heat to be carried out from the inside of the body to the skin with high efficiency. Body temperature moves from the blood through blood vessels to the body surface, so that the body surface becomes warm.[11,13]

The skin is the main source of heat loss during surgery and anesthesia, although evaporation from a wound incision is also important. High indoor air temperatures will maintain normothermic conditions in anesthetized patients. Operating room temperature settings, if operating room temperatures can be maintained between 25ºC - 26.6ºC then the patient's temperature can range below 36ºC but the temperature of 25°C is not comfortable for operating room personnel. In the ICU the room temperature is set lower to reduce the effect of spreading nosocomial infections. This is contrary to the purpose of giving warmers to postoperative hypothermia patients so that modification or intervention needs to be done other than increasing the room temperature.[15]

Covering the skin with surgical drapes or blankets can reduce heat loss from cutaneous. An insulating layer will reduce heat loss by as much as 30%, but the subsequent additional layers will not proportionally increase profits. For this reason, active warm-up efforts are needed to prevent perioperative hypothermia. Forced-air warming, is the most effective method, although there are other methods or combinations that can maintain a core temperature of 36°C. Circulating warm water mattresses are generally ineffective because blood flow to the back is limited to the supine position. Patients who undergo minor surgical procedures at warm ambient temperatures do not need active warmth, where forced-air warming with or without a combination of warmth liquids has helped to maintain normal intraoperative core temperatures in most cases.[6]

The use of a warm humidifier, a warm humidifier is another way to reduce hypothermia during anesthesia. In this way damage to the mucosa and cilia in the airways can be reduced because the moisture of the mucosa and cilia will be maintained properly. The temperature in the airway is maintained around 38ºC. The disadvantage of this intervention is that the warm humidifier liquid will quickly cool again due to exposure to low room temperatures.[6,15]

The use of heating lamps in a postoperative room can also warm the surface of the skin, because the thermoregulation system is more sensitive to the input of an increase in skin temperature. Warmers are electric lights that function to provide heat radiation to the skin resulting in an increase in body temperature. Temperature warming is intended to prevent hypothermia and reduce afferent input, namely by warming skin receptors, especially in areas with the greatest receptor density such as the neck, chest, and hands. While the disadvantage is that using a heating lamp directly can cause the skin to become red, especially the neck, chest, and hands because this tool has a high density in the thermoreceptors.[13]

Increasing skin surface temperature before induction of anesthesia can not significantly increase core temperature but increase peripheral tissue temperature and total body heat, thereby reducing temperature gradients. The NICE guidelines recommend raising the temperature before surgery if the temperature is < 36°C and keeping the patient comfortable and warm at 36.5°C - 37.5°C. Warming the skin surface only 30 minutes before induction of anesthesia is proven to prevent hypothermia carried out by Europe Monitoring and Managing Patient Temperature Study group.[15]

The provision of large amounts of cold liquid causes significant heat loss. One refrigerated blood unit or one liter crystalloid at room temperature can reduce body temperature by an average of 0.25°C. At flow rates < 35 ml/min, heating of fluids is not required in adults. Fluid heating is the only method that produces direct core heating and is recommended for all intraoperative infusions of 500 ml in adults. Liquids cannot be heated at temperatures much higher than normal body temperatures; most of the liquid warmers drain the fluid around body temperature. Red blood cells are stored at 4°C. Rapid transfusion (> 100 ml/min) can cause a sudden drop in temperature with serious consequences. According to WHO guidelines, maintaining a patient's warmth is more important than warming the blood; blood heating is necessary for the regulation of large volume transfusions (adults: > 50 ml/kg/hour; children: > 15 ml/kg/hour).[3]

Operating room temperature is the most important factor for determining changes in skin temperature through radiation, convection, and evaporation. Increasing room temperature is one way to minimize heat loss. Room temperatures over 23°C and 26°C are generally needed to maintain normothermia in adults and infants. Forced air blankets and radiant heaters are most commonly used to warm patients in the post-anesthesia recovery room. Because of the process of peripheral vasoconstriction, the efficiency is low and it takes a long time to warm up the patient. Active heating is better than passive heating alone in the postoperative phase. Active heating helps to regain the temperature one hour faster. Evidence shows that active heating by convection is slightly superior to conductive heating and radiation in the postoperative period.[3,16]

Definition of Hypertherm

Hypertherm is a state of increase in body temperature due to increased threshold regulation of heat in the hypothalamus. Perioperative hyperthermia can be caused by infection, noninfection and allergic reactions. Fever indicates an increase in the regulated core temperature targeted by the thermoregulation system. Fever develops when endogenous pyrogen increases the set point of the thermoregulation system. Fever is relatively rare under general anesthesia because volatile and opioid anesthetics inhibit the expression of fever. Perioperative fever can be caused by infection, improper blood transfusion, and allergic reactions.[14,20]

Hypertherm Mechanism

Fever refers to an increase in body temperature that is directly related to the level of pyrogen cytokines produced to cope with various stimuli. In response to pyrogenic stimulation, monocytes, macrophages, and kupfer cells secrete cytokines that act as endogenous pyrogens (IL-1, TNF-α, IL-6, and interferon) acting at the center of the hypothalamic thermoregulation. In response to these cytokines, prostaglandin synthesis occurs, especially prostaglandin E2 through the arachidonic acid metabolism of the cyclooxygenase-2 (COX-2) pathway and causes an increase in body temperature. The hypothalamus will maintain the temperature according to the new benchmark and not the normal temperature.[21]

Hypertherm Clinical Manifestations

Tachycardia is a response to peripheral vasodilation and the need for increased cardiac output. Peripheral vascular resistance is usually low unless there is severe hypovolemia. Compensatory vasoconstriction occurs in splanchnic and vascular kidneys. If the patient cannot increase cardiac output, hypotension develops. Various ECG changes increase the Q-T interval and unspecified ST-T changes. Thypypnea can cause significant respiratory alkalosis. Hypoglycemia can occur due to increased glucose utilization and impaired hepatic gluconeogenesis. The inflammatory response can cause or contribute to the clinical manifestations of hypertension.[22]

Temperature Reducing Mechanism

The body will have a mechanism to reduce the temperature when the temperature is too hot. The temperature regulation system uses three important mechanisms to reduce body heat, namely:

1. Vasodilation of blood vessels dilates. This is caused by obstruction of the sympathetic center in the posterior hypothalamus which causes vasoconstriction.[21]
2. Sweating: the effect of an increase in body temperature of 1°C causes enough sweating to remove 10 times greater basal metabolic rate than body heat formation.[22]
3. Decreased heat formation: mechanisms that cause excessive heat formation, such as chills and chemical thermogenesis, are strongly inhibited. Shivering can lead to an increase in unwanted heat production.[20]

Management of Hypertherm

Management to reduce body temperature without using drugs can be done with two methods of cooling namely conductive cooling and evaporative cooling. The type and amount of IV fluid must be adjusted based on electrolyte assessment and volume status. Too aggressive hydration can cause cardiac decompensation during cooling, especially in the elderly. Hypotension usually responds to cooling when peripheral vasodilation decreases. Vasopressor agents that produce vasoconstriction can reduce heat exchange and are not recommended for the initial management of hypotension. Evaporative cooling is a practical cooling method that is widely used. Airflow is created by using a fan to increase evaporative cooling.[21]

Conclusion

Body temperature varies at any time and is maintained within a normal range of between 36.5°C to 37.5°C at ambient temperature. Anesthetic action can eliminate the mechanism of adaptation and potentially disrupt the physiological mechanism of the function of thermoregulation. Hypothermia is a post-anesthesia complication that is often found in the recovery room, both post-general and regional anesthesia. Operating room temperature is the most important factor for determining changes in skin temperature through radiation, convection, and evaporation. Increasing room temperature is one way to minimize heat loss. Room temperatures over 23°C and 26°C are generally needed to maintain normothermia in adults. Covering the skin with surgical drapes or blankets can reduce heat loss from cutaneous. For this reason, active warm-up efforts are needed to prevent perioperative hypothermia. The use of heating lamps in a postoperative room can also warm the surface of the skin, because the thermoregulation system is more sensitive to the input of an increase in skin temperature.

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