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Review

Hypothermia in elective surgery: The hidden enemy☆

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ABSTRACT

Introduction: Hypothermia is perhaps the most frequent undesirable event in elective surgery. It is estimated that 1 h after surgery has initiated 70–90% of patients will experience hypothermia. In elective surgery, there are several factors leading to temperatures under 34 °C. Hypothermia may increases infections, bleeding and need for transfusion as well as the occurrence of an undesirable effect of discomfort and feared such as cold and postoperative shivering that can lead to cardiac complications due to increased of sympathetic influence.

Objectives: Review the causes of these low temperatures within intraoperative elective surgery and check if the current alternatives to prevent hypothermia are effective.

Methods: Review of non-systematic literature in PubMed and Medline was performed.

Results: Hypothermia is the most common and least diagnosed undesirable event of patients undergoing surgery although it is easy to detect and preventive measures do not present major difficulties in their implementation.

Conclusions: There are effective measures easy to set up, economical and effective to prevent hypothermia; the most important is the patient warm with hot air under pressure for 1 h and maintenance of air conditioning in the room above 22 °C. We just need to understand these measures and start to implement them.

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Hipotermia en cirugía electiva. El enemigo oculto

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RESUMEN

Introducción: La hipotermia es tal vez el evento indeseable mas frecuente en los pacientes que van a cirugía programada. Se considera que 1 hora después de iniciada la cirugía el 70 al 90% de los pacientes se encuentran hipotérmicos. En cirugía Electiva en pacientes sanos hay varios factores que llevan a que nuestros pacientes mantengan cifras de temperaturas de 34 °C e inclusive menores. El problema está en que la hipotermia aumenta las infecciones, el sangrado y la necesidad de trasfusión, la aparición de un efecto indeseable y temido por el paciente como es el frío y temblor postoperatorio que puede llevar a complicaciones cardiacas debido al aumento del influjo simpático.

Objetivos: Revisar las causas que llevan a estas bajas temperaturas intraoperatorias en cirugía programada y revisar si las opciones que tenemos hoy en día para prevenir la hipotermia pueden ser efectivas.

Métodos: Se realizó una revisión de la literatura no sistemática en las bases de datos PubMed y Medline.

Resultados: La hipotermia es el evento indeseable más frecuente y menos diagnosticado en el paciente que va a cirugía a pesar que es fácil de detectar y las medidas preventivas son relativamente fáciles de instaurar.

Conclusiones: Hay medidas efectivas, fáciles de instaurar, económicas y efectivas para evitar la hipotermia y entre ellas la más importante es el precalentamiento del paciente con aire caliente a presión por 1 hora, el mantenimiento del aire acondicionado de la sala por encima de 22 grados centígrados. Solo necesitamos entender cuales son estas medidas e iniciar a ponerlas en practica.

Introduction

Hypothermia is the hidden enemy in most elective surgery procedures. Very few anesthesiologists and surgeons take into account this problem intraoperatively despite all the adverse effects caused in the postoperative period. It is considered that 70–90% of patients undergoing surgery develop hypothermia even if surgery only takes 1 h. The restoration of normothermia can take up to 4 h if measures for preventing hypothermia are not taken. Both general and regional anesthesia, contribute to deteriorate protective mechanisms of hypothermia. In addition to the known effects of hypothermia such as increased infection rate, impairment of clotting mechanisms and major bleeding, there are adverse events due to the inevitable tremors that cause great discomfort and unpleasant feeling.

Methodology

A non-systematic literature review was performed in databases such as PubMed and Medline, entering keywords in English: hypothermia in plastic surgery, complications of hypothermia, prevention of hypothermia, maintaining normothermia. The articles were read, those referring to the subject were consulted and according to this methodology 52 references were selected. The results of this review are presented below.

Review

Thermoregulation in humans

Human being is homeothermic and endothermic. This means that, in addition to maintaining its temperature in narrow ranges, can produce heat by itself. In simple terms, the human body is divided into two compartments, one central that produces heat and one peripheral that regulates heat loss. Our tight regulatory mechanisms are made to protect our central compartment at the expense of the peripheral. Thus, the core temperature, and especially the temperature in the brain, is regulated close to 37 °C, with an almost perfect thermoregulation, but at the expense of the skin, which is actually poikilothermic and its temperature resembles the ambient temperature about 33 °C. Under normal conditions, the production of body heat is the result of the basal metabolic rate of internal organs such as the brain and those of the thoracic and abdominal cavity as heart, lung, liver, intestine and kidney. Blood passes through these organs is heated and then is distributed by the cardiovascular system by convection from the central region to skin region.[1–4]

The core that integrates and regulates body temperature and actually acts as a thermostat is in the posterior hypothalamus. Thus the blood temperature that reaches the hypothalamus is the major determinant of the body's response to climate change and is responsible for maintaining a balance between heat production and heat transfer processes (gain and loss).

These transfer processes between our body and the external medium is produced in two ways: by evaporation and no evaporative mechanisms (radiation, conduction and convection).

According to the second law of thermodynamics heat can only flow by temperature gradient from the body that is warmer toward the periphery or the environment that is colder, therefore, the body never can be heated from the periphery to the core which is usually warmer than the outside.

Body temperature regulation mechanisms

Body temperature is regulated exclusively by nervous mechanisms of negative feedback operating in the thermoregulatory centers in the hypothalamus. In few cases, body temperature can only be altered by internal heat generation, regularly is by cooling or heating of the environment. For its part, transient receptor potential (TRP) channels in the skin are widely present in sensory neurons. TRPM8 subtype exhibits activation at a room temperature <27 °C that is when there is a slight cold. The central thermoreceptors are located in the brain, spinal cord and abdomen. Lateral parabrachial nucleus neurons are activated by cooling signal, which promotes an excitatory influx aimed at GABAergic interneurons. This GABA influx inhibits inhibitory neurons in the preoptic area in the hypothalamus, which is the area in charge of temperature control, among other functions. The result is the disinhibition of thermogenesis-promoting neurons in the hypothalamus. The spinal sympathetic influx and somatic motor circuits are activated by these fibers to trigger thermogenesis.[5–7] Thus, the coordination of a thermoregulatory response with a perfect hierarchical organization takes place from the preoptic area of the anterior hypothalamus, coordination that goes far beyond a simple spinal cord response as vasoconstriction.

A symphatic spinal flow is triggered with a large release of adrenaline and noradrenaline due to hypothermia, which produces an extensive peripheral vasoconstriction with arteriovenous shunts that reduce the blood flow to these cold peripheral areas and, in turn, keeps the warm blood in the central compartment. Thus we have a gradient between the central and peripheral temperature, which can be 2–4° with peripheral temperatures of 32 °C and centrals of 36 °C or lower.[8]

Anesthetics effects on the heat conservation mechanisms

All inhaled anesthetics impaired deeply the autonomic responses that defend us from hypothermia. These responses are given in therapeutic ranges, thus interthreshold range may increase 10–20 times (4 °C), meaning that the response of peripheral vasoconstriction, usually given at 37 °C with inhaled anesthesia, can be given at 34 °C or 35 °C. It means being totally exposed to hypothermia during surgery; regional anesthesia may increase the range only 3 or 4 times, but also has a direct vasodilator effect that deteriorates the response to cold.[9]

Hypothermia phases during general anesthesia

Temperature changes occur in three phases during anesthesia.[10] The greatest decline takes place during the first phase; temperature drops from 1 °C to 1.5 °C in the first hour due to a redistribution of heat from the center to the periphery. Heat loss in this phase is the result of the normal gradient, from 2 °C to 4 °C, between the core to the periphery and the vasodilatation that exists at the peripheral level due to the loss of the mechanisms of vasoconstriction by anesthesia.[11–13]

During the second phase (second and third hour) occurs a slow linear reduction of temperature due to central heat loss by decreased of basal metabolism. Hypothermia is also exacerbated by the low temperatures in the operating room, the body sites exposed (for example in liposuction) and the amount of cold liquids infiltrated subcutaneously.

In the third phase (third and fourth hour) or plateau, temperature maintains a relatively stable state. In this phase, normally between 34 °C and 35 °C, the mechanisms of protection against lost hypothermia such as vasoconstriction and the closure of shunts in hands and feet, are activated again. At this stage the heat loss is minimized, but it never gets to reheat the body.

Regional anesthesia and hypothermia

Hypothermia is frequent in both general and regional anesthesia. Some studies may show that the loss of temperature may be slightly lower in the first hour with regional anesthesia (0.8 °C) versus general anesthesia (1.2 °C)[14–16] while others have shown no difference. Phases 1 and 2 are almost equal to the general anesthesia ones, but the phase 3 has complications. Vasoconstriction is not activated at 34 °C with regional anesthesia, therefore, in this third phase (phase Plateau in general anesthesia) heat loss may continue in the patient, after 3 or 4 h. Thus, hypothermia can become even more serious with regional anesthesia, especially during lengthy surgery.[17,18] Hypothermia is more severe, depending on the dermatomes blocked and hence of the sympathetic blockade. Some studies have shown a decrease in 0.15 °C per dermatome blocked.[19] In plastic surgery this is a matter of great concern since very extensive blockages are performed that might include the thoracolumbar system in cases of tummy tucks and breast procedures with double puncture.

Hemodynamic and autonomic effects in response to cold

Even mild hypothermia (1–2 °C), Norepinephrine values increase up to 7 times that generate a considerable hyperdynamic response. It has been proved that this can cause morbid cardiac events in susceptible individuals.[20–22]

According to a study published by Frank (1993),[23] which compares normothermic patients versus hypothermic patients intraoperatively, it was found the latter was three times more risk of myocardial infarction and 12 times more risk of angina.

Hematologic effects

Hypothermia increases blood viscosity which can lead to a deterioration of perfusion. Hematocrit levels rises by 2% per 1 °C decline in temperature. This false hematocrit increase can be misleading in a hypothermic patient with blood loss.[24] It also has deleterious effects on the coagulation cascade; hypothermia decreases all enzymatic reactions involved in the intrinsic and the extrinsic pathway. It has been shown that both the partial thromboplastin time (PTT) and prothrombin time (PT), are increased significally by hypothermia in surgery in regards to normothermic patients.[25,26] Furthermore hypothermia causes transient thrombocytopenia and reduces platelet function by a transient decrease of thromboxane synthesis B2.[27,28] A prospective controlled study by Cavallini[29] found that the group with intraoperative hypothermia presented partial times higher than thromboplastin preheated group, of which it was concluded that maintaining normothermia is one of the main strategies to reduce both intraoperative bleeding as the need for transfusions.

Effects on the immune system

Hypothermia has an immunosuppressive effect that lowers resistance to infection. It has been shown in vitro that low temperatures decrease leukocyte migration; reduces neutrophil phagocytic capacity;[30] decreases production of interleukins 1, 2 and 6 and the tumor necrosis factor;[31] antibody production decreases in T cells, while both complement activation and levels of C-reactive protein are deteriorated. Melling et al.[32] conducted a study in patients with clean surgical procedures (such as breast surgeries) and found that the group without warming had infection rates much higher than groups that underwent prewarming (15% vs 6% and 4%).

Hypothermia classification

The tympanic membrane, nasopharynx, esophagus and the distal pulmonary artery are the most accurate sites to monitor core temperature.

Hypothermia is defined as a body core temperature below 36 °C and classified as mild (36–32 °C), moderate (28–31.9 °C) and severe (less than 28 °C).[33] However, Kirkpatrick,[34] has classified hypothermia in four phases, making a division of the mild phase; one of 36–34 °C and other of 34–32 °C.

Risk factors for perioperative hypothermia in plastic surgery

The most important risk factors include the air conditioning in the operating room, combine general and regional anesthesia, prior patient temperature < 35.5 °C, blood loss > 30 cc/kg[35] and the removal of fat in liposuction which also contributes to the hypothermia in this type of surgery.[36]

Heating methods to prevent intraoperative hypothermia

Preventing hypothermia can ensure safer and pleasurable surgery. The aim is to avoid the temperature drops below 36 °C, so it is essential monitoring body temperature by a probe.[37,38] Studies conducted in Colombia show that temperature is monitored only in 10% of patients undergoing surgery and this leads us to ignore the magnitude of the problem.[39] One of the most important and effective measures, but also less implemented due to the discomfort for the entire surgical team is to maintain operating room temperatures above 22 °C,[40] but this has been little used in practice.

Effects of prewarming

Prewarming is perhaps the most important measure to prevent hypothermia in surgical. The patient can be prewarmed before surgery with a forced warm-air blanket system 30 min to 1 h. Raising the external temperature has little or nothing effect on the core temperature, however, this reduces the difference or temperature gradient between the core and the periphery and thus heat loss reduces by decreasing the delta temperature during the first hour of anesthesia and surgery, time in which fastest loss temperature occurs.[41–43] During this first hour loss temperature decreases up to 2 °C in patients without prewarming vs 0.9 °C in patients prewarmed.[44,45] Sessler[46] determined 1 h as the ideal time to the patient should be prewarmed to significantly reduce heat loss during the first hour of surgery.

Hot water mattress

Although hot water mattresses have been widely used for decades and are considered as the classic heating system in surgery, actually their effectiveness is limited: the back is just a portion of the total body surface area and 90% of core heat is lost from the previous area of the body. In addition hot water mattresses have been associated with burned areas in pressure zones.[14,47,48]

Warming intravenous fluids

It is known that 1 l of saline solution intravenously infused at room temperature decreases the temperature in adults 0.25 °C.[49] However, this is not the main cause of heat loss in plastic surgery patients in which the liquid handling is conservative, although some studies have shown that patients, who were infused with heating systems IV such as Hotline, could have some thermal benefit compared to those without any measure of thermal protection liquid.[50] Heaters should be an alternative only if IV fluids exceed 2 l per hour as in the case of resuscitation or emergency surgery.

Warming of liquids infiltration in plastic surgery

One of the main reasons why hypothermia is common and severe in plastic surgery (liposuction in particular), is the large amount of liquids that are placed in subcutaneous infiltration. The most common in liposuction is to perform infiltration/aspiration ratios ranging from 1:1 with the super-wet technique. This means that in a 4-l liposuction, 4 l of normal saline solution should be infiltrated subcutaneously, which is usually done with liquid at room temperature. A study conducted by Robles-Cervantes et al.[51] compared the heat loss by using infiltration at room temperature (24 °C) versus liquids prewarmed to 37 °C. In the latter case temperatures raised 35.7 °C against 34.9 °C in the group without prewarmed. For this reason is considered an effective measure.

Conclusions

Preventing hypothermia allows a safer surgery and a more pleasant postoperative recovery. Prevention measures result in great benefits such as reducing the rate of infections, improvement in cicatrization, less blood loss, less need of transfusion and a fast and pleasant wake up after anesthesia. Our goal is to avoid the patient temperature drops below 36 °C. For this, the first step is a continuous monitoring of the core temperature during surgery. To achieve this aim the three most important measures are in order (1) prewarmed the patient with forced air blankets for 1 h before surgery, (2) prewarmed of infiltration liquid at 37 °C in the case of plastic surgery and (3) maintenance air conditioning in operating rooms above 22 °C. All these measures are preventive, easy to implement and economic. Finally, it is important to highlight the need of specific studies about the temperature in the different specialties.

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Conflicts of interest

Dr. Jorge Enrique Bayter-Marín is the coordinator of the Anesthesia Committee for Plastic Surgery at S.C.A.R.E.

Dr. Jorge Rubio is the coordinator of the Committee of Ambulatory Anesthesia at S.C.A.R.E.

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