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The effect of anesthesia on body temperature control

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1. ABSTRACT

The human thermoregulatory system usually maintains core body temperature near 37 degrees C. This homeostasis is accomplished by thermoregulatory defense mechanisms such as vasoconstriction and shivering or sweating and vasodilatation. Thermoregulation is impaired during general anesthesia. Suppression of thermoregulatory defense mechanisms during general anesthesia is dose dependant and mostly results in perioperative hypothermia. Several adverse effects of hypothermia have been identified, including an increase in postoperative wound infection, perioperative coagulopathy and an increase of postoperative morbid cardiac events. Perioperative hypothermia can be avoided by warming patients actively during general anesthesia. Fever is a controlled increase of core body temperature. Various causes of perioperative fever are given. Fever is usually attenuated by general anesthesia. Typically, patients develop a fever of greater magnitude in the postoperative phase. Postoperative fever is fairly common. The incidence of fever varies with type and duration of surgery, patient's age, surgical site and preoperative inflammation.

2. INTRODUCTION

The human thermoregulatory system usually maintains core body temperature near 37 degrees C. When internal temperature deviates significantly from normal, metabolic functions usually deteriorate. Perioperative deviations from normothermia are common with hypothermia being the predominant thermal derangement. Hypothermia results from anesthetic-induced inhibition of thermoregulatory control combined with exposure to a cool environment.

2.1. History

As early as 1888 Hare published in the journal *Therapeutic Gazette* that temperature dropped during the application of ether (1). Similarly in 1907, Davis suggested that the body would loose heat by radiation in cold operating rooms during general anesthesia (2). Other reasons noted for anesthesia-induced hypothermia were decreased metabolism, cutaneous vasodilatation, and decreased muscular activity (3). Later, Hemingway proposed that barbiturates impair thermostatic reflexes thereby causing hypothermia (4). It was also reported that

patients became hyperthermic under general anesthesia. Hyperthermia was attributed to high ambient temperature in (non-air conditioned) operating rooms (5, 6).

In the early 1960s human thermoregulation began to be studied extensively. In 1966 Goldberg recorded rectal temperatures in 101 adult surgical patients undergoing general anesthesia. He found that temperature was increased in 5% of patients, unchanged in 18%, and reduced in 78%. He attributed the observed temperature derangements to an imbalance between heat loss and heat production during general anesthesia (7). Sporadic reports continued to appear regarding body temperature variations during anesthesia until the mid 1980s (8). Since then the interaction between thermoregulation and anesthesia has been studied extensively and systematically (9). This article provides an overview of the effects of anesthesia on thermoregulation.

3. NORMAL THERMOREGULATION

Core body temperature in humans is a tightly controlled vital parameter. Temperature control is accomplished by the processing of thermoregulatory information, which occurs in three phases: afferent thermal sensing, central regulation, and efferent responses. Environmental temperature is thought to be sensed directly by neurons through their projections in the skin. A subset of the mammalian transient receptor potential (TRP) family of excitatory ion channels has been implicated in this process. Different thermal TRPs (10) are activated at distinct temperature thresholds and are typically expressed in sensory neurons (11). Sensory neurons of both cold and warm temperature receptors are widely distributed. Cold signals are transmitted via A-delta fibers. In contrast, signals from warm receptors are conveyed by C fibers. The neuronal information is then integrated at numerous levels within the spinal cord and central nervous system. All thermal information gets collected in the hypothalamus, the highest integrated center for thermoregulatory control in the brain of mammals (12).

Broadly speaking, there are two types of thermoregulatory responses to temperature control: behavioral and autonomic responses. Behavioral responses seem to be more dependent on mean skin temperature (13). Behavioral strategies are mediated by thermal discomfort, which provokes responses to adjust to ambient temperature. Behavioral responses include putting on clothes or seeking shelter in cold environments and taking off clothes, turning on air conditioning, or fanning oneself in hot environments.

Autonomic responses depend on thermal input from deep abdominal and thoracic tissues, and from the spinal cord, hypothalamus, and other portions of the brain, each of which contributes roughly 20% to autonomic thermoregulatory control. Mean skin temperature also contributes roughly 20% to control of autonomic responses (14, 15). During anesthesia, the patient is rendered unconscious and thus unable to make any behavioral response to temperature change leaving the autonomic responses as the only remaining defense mechanism to temperature changes.

3.1. Autonomic thermoregulatory defenses

3.1.1. Sweating and vasodilatation

The primary autonomic defenses against heat are sweating and vasodilatation, which are referred to as warm responses. Sweating is mediated by post-ganglionic, cholinergic nerves that terminate on widely, but unevenly, distributed glands. Sweat is an ultrafiltrate of plasma whose composition depends on the rate of sweating, hydration status, and a number of other factors. The maximum sweating rate exceeds 0.5 liters/hour in most adults, but is two- or three-fold greater in trained athletes (16). Each gram of sweat absorbs 584 calories, presumably by evaporation. Consequently, sweating can easily dissipate many times the basal metabolic rate in a dry environment. The efficacy of sweating is augmented by pre-capillary thermoregulatory vasodilatation.

Active thermoregulatory vasodilatation is a uniquely human response that is mediated by unknown factors released from sweat glands. Nitric oxide (NO) and NO synthase may play a role in mediating active vasodilatation (17), although not exclusively (18). Vasodilatation increases cutaneous blood flow significantly. Increased blood flow facilitates transfer of heat from the core to the skin for eventual dissipation to the environment (19).

3.1.2. Vasoconstriction

The primary defense mechanisms against cold are arterio-venous shunt vasoconstriction and shivering, the cold responses. A cold environment or the onset of fever can both trigger thermoregulatory vasoconstriction and shivering. Thermoregulatory vasoconstriction occurs in arterio-venous shunts located primarily in fingers and toes. Although these shunts are limited in their anatomical distribution, when activated they exert a profound effect on core body temperature. Arterio-venous shunts are controlled by centrally mediated alpha-1 adrenergic receptors; in addition, constriction is synergistically augmented by local hypothermia via alpha-2 adrenergic receptors (20).

Shunts are typically about 10 times larger in diameter (100 micrometers) than capillaries. However, open shunts allow a blood flow that is about 10,000 times higher than a 10-micrometer capillary of equal length according to the Hagen–Poiseuille equation. Arterio-venous shunt vasoconstriction can reduce fingertip and toe heat loss by 50% with the consequence that arms and legs gradually cool and heat will be constrained to the core thermal compartment, which consists of the trunk and head. Thus, less heat will be allowed to escape into peripheral tissues and, consequently, into the environment (21).

3.1.3. Shivering

Shivering is an involuntary muscular activity that increases metabolic rate about two-fold. This is a relatively small increase of the metabolic heat compared with that of muscle activity during strenuous exercise during which the

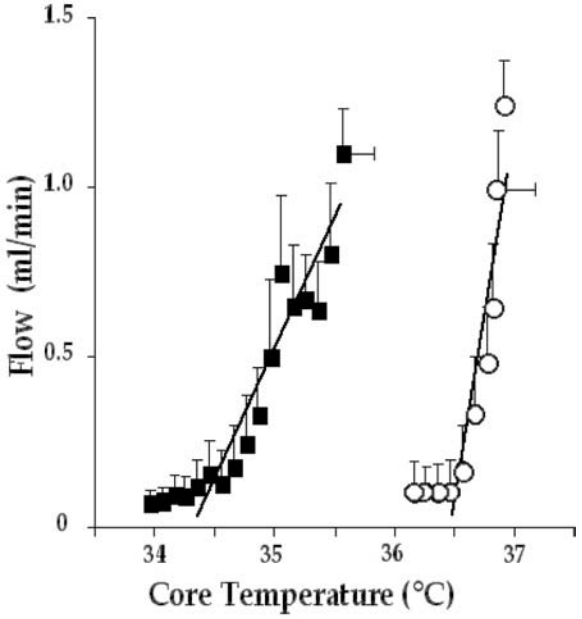

Figure 1. Gain and maximum intensity of vasoconstriction as measured by arterio-venous shunt flow as a function of core temperature in awake subjects (open circles) and during general anesthesia with desflurane (solid squares). Reproduced with permission from Wolters Kluwer (37).

metabolic rate can increase ten-fold. Consequently, core body temperature increases significantly more than seen with involuntary shivering. Thus, shivering triggered by a core body temperature decline is remarkably ineffective.

Thermoregulatory shivering has a typical pattern with a phase of rapid tremor of up to 250 Hertz and an unsynchronized muscular activity (22). During intense shivering, a pattern of waxing and waning with 4 to 8 cycles per minute can be observed (23). Thermoregulatory shivering always follows vasoconstriction as a second line thermoregulatory defense mechanism. It contributes to the increase in core body temperature in hypothermic individuals and in patients who are getting a fever. Shivering may be mediated by efferent signals from the preoptic region of the hypothalamus via the medial forebrain bundle. A central descending pathway probably mediates the information to spinal alpha motor neurons, where muscles are activated for both coordinated muscular activity and shivering.

3.2. Characteristics of autonomic thermoregulatory defense mechanisms

Autonomic thermoregulatory defense mechanisms are characterized by thresholds, gains, and maximum response intensities. Thresholds are defined by the core temperature triggering a thermoregulatory defense (at a given mean skin temperature); gain characterizes the extent to which response intensity increases with further deviation from the triggering threshold. The thermoregulatory system usually maintains core temperature within 0.2 to 0.4 degrees C of the target value (24, 25). This target value is time-adjusted; that is, it follows a circadian rhythm. The precision of thermoregulatory control is similar in men and women, but is diminished in the elderly (26).

Sweating and active vasodilatation are triggered simultaneously. In contrast, vasoconstriction will usually be triggered before shivering occurs. Body temperature is normally maintained between the sweating and the vasoconstriction thresholds. These thresholds are defined as temperatures that provoke the onset of thermoregulatory response mechanisms. The zone between these thresholds has been termed null zone or interthreshold range.

Interthreshold range may be seen as a setpoint that is guarded by the hypothalamus. If there is a deviation of body temperature from a given setpoint, the hypothalamus reacts like a home thermostat, in which heating or cooling is either set to “on” or “off.” If body temperature continues to deviate further from the setpoint, defense mechanisms become stronger until the mechanism reaches a maximum intensity. The increase in intensity is called gain and can be measured by the change of intensity along the change of core body temperature. Maximum intensity identifies the point at a certain core temperature at which there is no more increase in intensity (Figure 1).

4. ANESTHESIA AND THERMOREGULATION

4.1. General anesthesia

General anesthesia eliminates behavioral thermoregulatory compensations, leaving only autonomic defenses to offset environmental perturbations. Anesthesia inhibits thermoregulatory control and this inhibition is dose-dependent. It impairs the vasoconstriction threshold about three times as much as the sweating threshold. General anesthetics linearly increase the warm-response thresholds, as do opioids to a lesser extent (27) (Figure 2). Opioids and the intravenous anesthetic propofol linearly decrease the vasoconstriction and shivering thresholds (27, 28). The sedative dexmedetomidine, an alpha-2 agonist, causes a similar reaction (29). In contrast, volatile anesthetics, such as isoflurane (30), desflurane (31), sevoflurane, and halothane (32) decrease cold responses non-linearly. Typical anesthetic doses thus increase the interthreshold range (core temperatures not triggering thermoregulatory defenses) 5 to 20-fold from its normal range of approximately 0.2 degrees C. The shivering threshold follows the same dose-dependant pattern with most anesthetics with two exceptions: nefopam and meperidine. Nefopam is a non-sedative benzoxacozine analgesic that selectively reduces the shivering threshold without affecting the vasoconstriction threshold (33). Meperidine is the oldest artificial morphine derivative. Meperidine possesses additional anti-shivering potential; it inhibits the shivering threshold twice as much as the vasoconstriction threshold (34). The only drug commonly used in anesthesia that does not effect thermoregulation is the benzodiazepame midazolam (35).

Each thermoregulatory defense mechanism has a characteristic gain and maximum intensity, as well as a thermoregulatory threshold. During general anesthesia with

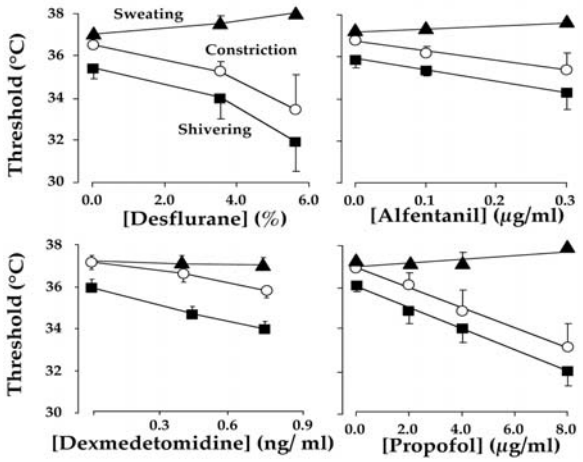

Figure 2. Various drugs (volatile anesthetics, narcotics, alpha-2 agonists, propofol) used in anesthesia show a dose dependant effect on threshold temperatures for sweating (solid triangles), vasoconstriction (open circles) and shivering (solid squares). Reproduced with permission from Wolters Kluwer (47).

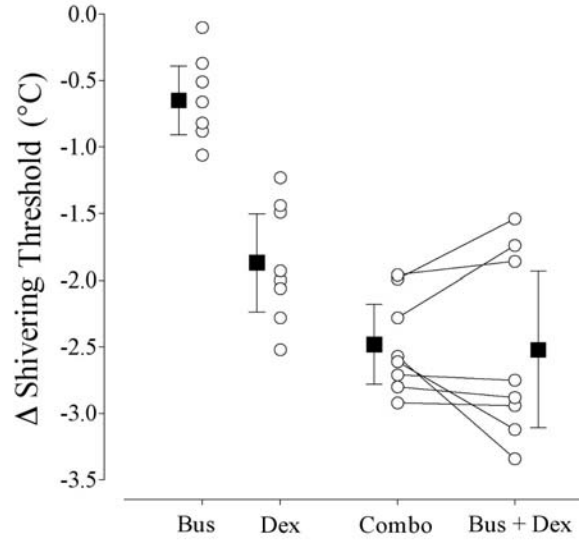

Figure 3. Reductions in the shivering threshold (compared with Control day) for buspirone (Bus), dexmedetomidine (Dex), and combined Bus and Dex (Combo) days. Also shown is the expected reduction for the combination of buspirone and dexmedetomidine — calculated as the sum of the individual effects — assuming the two drugs had an additive effect. Squares represent group means ± SDs. Open circles represent the value for each of the eight volunteers. Reproduced with permission from Wolters Kluwer (43).

volatile anesthetics, the thresholds of sweating and active vasodilatation are slightly higher, while gain and maximum intensity are well preserved (36). In contrast, the gain of arterio-venous shunt vasoconstriction is reduced three-fold by desflurane, without altering the maximum intensity (37) (Figure 1). Isoflurane changes the macroscopic pattern of shivering to such an extent that it is no longer possible to easily determine gain. The drug does, however, reduce maximum shivering intensity (38). Gain and maximum shivering intensity remain normal during both meperidine and alfentanil administration (39)**.** Gain also remains nearly intact during nitrous oxide administration, although maximum intensity is reduced (40).

Certain drug combinations further decrease the thresholds for vasoconstriction and shivering. Tested drug combinations are meperidine and buspirone (41), meperidine and dexmedetomidine (42), and dexmedetomidine and buspirone (43) (Figure 3). Likewise, the combination of meperidine and body surface warming additively reduces cold response thresholds (44). Meperidine and buspirone combined act synergistically, while the all other tested combinations exert their effects additively (Figure 3). The above-mentioned combinations are used to suppress shivering during therapeutic hypothermia in critically ill patients.

4.1.1. Heat balance during general anesthesia

During general anesthesia inadvertent hypothermia is by far the most common perioperative thermal disturbance; it results from a combination of anesthetic-impaired thermoregulation as outlined above and exposure to a cold operating room environment. Heat balance and its changes play a dominant role in this process.

Normally, heat loss and heat production form an equilibrium allowing a thermal steady state, which keeps core temperature constant. Temperatures of the peripheral tissues (also referred to as the peripheral compartment) are lower than core temperature (core compartment). Usually, there is a 2 to 4 degrees C gradient between temperatures in the core and peripheral compartment. This gradient is maintained by tonic thermoregulatory vasoconstriction resulting in an uneven distribution of heat (15). Thus, peripheral tissues function as a thermal buffer. Due to their mass, the legs constitute the major portion of the peripheral buffer. The capacity of the peripheral compartment is approximately 150 kcal, allowing for a significant change in body heat without losing control over the tightly maintained core temperature.

Induction of general anesthesia impairs thermoregulatory control by reducing the vasoconstriction threshold to a lower core temperature, thereby opening or keeping arterio-venous shunts open at lower core temperatures (30). Consequently a redistribution of body heat results as heat flows from the core compartment to the peripheral tissues. During the first hour of anesthesia this redistribution accounts for about 80% of the core temperature decline, but there is little net heat loss overall (45). Core temperature drops by about 1 to 1.5 degrees C, while peripheral tissue temperatures gain up to 2 degrees C.

After completion of the redistribution, core temperature usually decreases at a slower rate. This decrease is nearly linear and results from heat loss exceeding metabolic heat production (46). The main reasons for this imbalance are exposure of the body to a

cold operating room environment, evaporation of cold surgical skin prep solutions, loss of heat from surgically exposed sites, and a reduction of metabolic heat production as a result of general anesthesia. Approximately 90% of all heat is lost via the skin surface, with radiation and convection usually contributing far more than evaporative or conductive losses.

When patients have become sufficiently hypothermic, core temperature often stops decreasing during general anesthesia. This phase is often referred to as the plateau phase and occurs after 3 to 5 hours of general anesthesia. The plateau results from re-activation of thermoregulatory vasoconstriction, which decreases cutaneous heat loss and constrains metabolic heat to the core thermal compartment (27, 30). Intraoperative vasoconstriction thus re-establishes the normal core-to-peripheral temperature gradient by preventing loss of centrally generated metabolic heat to peripheral tissues. Vasoconstriction produces a four-fold reduction in the core-cooling rate. This core-temperature plateau may also be a simple thermal steady state, with heat loss equaling heat production. The plateau is especially likely in patients who are well insulated or effectively warmed.

From a clinical point of view, an active core-temperature plateau is potentially dangerous because mean body temperature and body heat content continue to decrease, although core temperature remains constant. Because vasoconstriction is effective, intraoperative core temperature rarely decreases the additional 1 degree C necessary to trigger shivering. Shivering during general anesthesia is thus uncommon. However, shivering can be seen in sedated critical care patients.

In summary, intraoperative hypothermia is common if the patient is not warmed actively. Fortunately, effective active warming devices are currently used perioperatively to reduce the development of hypothermia. Inadvertent hypothermia develops in three phases. Initially, core temperature drops quickly, secondary to a redistribution of heat from the core to the peripheral compartment. The heat flow is facilitated by an inhibition of anesthesia-induced vasodilatation. In a second phase, there is a slower and linear decline of core temperature because of an imbalance between heat loss and heat production. Once vasoconstriction kicks in at significantly decreased vasoconstriction threshold temperatures, core temperature stops to decrease and a plateau phase is reached (47).

4.2. Neuraxial anesthesia

Neuraxial anesthesia comprises spinal and epidural anesthesia. Neuraxial anesthesia impairs both central and peripheral thermoregulatory control. As a result, hypothermia is common in patients given spinal or epidural anesthesia. Despite transient paralysis of the lower body, hypothermia commonly provokes shivering in the upper body.

Nerve blocks prevent regional manifestation of the major thermo-regulatory defenses including sweating, vasoconstriction, and shivering. Spinal and epidural anesthesia disrupt nerve conduction to more than half the body. This peripheral inhibition of thermoregulatory defenses is a major cause of hypothermia during regional anesthesia. For example, epidural anesthesia halves the gain and maximum intensity of shivering.

Regional anesthesia, however, also impairs central thermoregulatory control, and the amount of inhibition is proportional to block height (48). Although regional anesthesia *per se* has no direct central effect, it inhibits central control. Inhibition is similar with spinal and epidural anesthesia (49) and does not result simply from recirculation of local anesthetic to the brain. While the specific mechanisms remain unclear, the vasoconstriction and shivering thresholds are typically reduced 0.5 degree C whereas the sweating threshold is elevated 0.3 degree C (50). The result is a 3-fold increase in the normal interthreshold range. In addition, epidural anesthesia reduces the gain of shivering, which suggests that the regulatory system is unable to compensate for lower body paralysis (51). Thermoregulatory defenses, once triggered, are therefore less effective than usual during regional anesthesia. Clinically, anesthetic-induced thermoregulatory inhibition is frequently compounded by concomitant administration of sedatives.

Regional anesthesia typically causes core hypothermia; however, patients often feel warmer after induction of anesthesia (52, 53). Because core-temperature monitoring is still rare during spinal and epidural anesthesia and because patients often fail to recognize that they are cold, hypothermia commonly goes undetected during regional anesthesia.

4.2.1. Heat balance during regional anesthesia

Core hypothermia is nearly as severe during regional as during general anesthesia. As during general anesthesia, the initial hypothermia results from a core-to-peripheral redistribution of body heat. In this case, however, redistribution results primarily from peripheral rather than central inhibition of tonic thermoregulatory vasoconstriction. Although arterio-venous shunt vasodilatation is restricted to the lower body, the mass of the legs is sufficient to produce substantial core hypothermia. Subsequent hypothermia results simply from heat loss exceeding heat production. Patients given spinal or epidural anesthesia cannot, however, develop a regulated core-temperature plateau because vasoconstriction remains peripherally impaired. Consequently, hypothermia tends to progress throughout surgery.

Patients becoming sufficiently hypothermic during spinal or epidural anesthesia shiver. Shivering is discomforting to patients and disturbing for caregivers, but produces relatively little heat because it is restricted to the small muscle mass cephalad to the block.

4.3. Consequences of inadvertent hypothermia during anesthesia

Perioperative hypothermia is a common and serious complication of anesthesia and surgery and is associated with many adverse perioperative outcomes. It

prolongs the duration of action of inhaled and intravenous anesthetics (54), as well as the duration of action of neuromuscular drugs (55). Mild core hypothermia increases thermal discomfort (56), and is associated with delayed postanaesthetic recovery (57). Mild hypothermia significantly increases perioperative blood loss and augments allogeneic transfusion requirement (58, 59). Only 1.9 degrees C core hypothermia triples the incidence of surgical wound infection following colon resection and increases the duration of hospitalization by 20% (60). Hypothermia adversely affects antibody- and cell-mediated immune defenses (61), as well as the oxygen availability in the peripheral wound tissues. Furthermore mild hypothermia triples the incidence of postoperative adverse myocardial events (62). Thus, even mild hypothermia contributes significantly to patient care costs and needs to be avoided.

4.4. Avoiding hypothermia during anesthesia

Four different mechanisms contribute to perioperative heat loss: evaporation, conduction, radiation and convection. Several methods have been developed to avoid inadvertent perioperative hypothermia. The most widely used method is cutaneous warming, which can be achieved with forced air warming covers (63) and circulating water garments (64). In addition, electric resistive heating blankets have been introduced into clinical practice (65). In contrast, heating intravenous fluids does not warm patients, but contributes to prevent fluid-induced hypothermia in patients given large volumes of fluid (66). The easiest way to radically reduce heat loss by the body surface is to increase ambient temperature, since operating room temperature is the most critical factor influencing heat loss (67). However, this method is impractical, as most operating room personnel find ambient temperatures above 22 degrees C uncomfortably warm.

4.5. Anesthesia and fever

4.5.1. Causes of perioperative fever

Etiologies of perioperative fever include infection, non-infectious inflammation, allergic reactions (68), and blood in the fourth cerebral ventricle (69). Various drugs — including penicillins, phenytoin, and anticholinergics — may provoke a fever in patients undergoing surgery (70). Likewise, patients may present with fever after major trauma that requires emergency surgery. Perioperative fever can also be observed in patients undergoing surgery for tumor resection or in patients suffering from autoimmune diseases. Fever is accompanied by a constellation of host responses that collectively define the acute-phase response. Acute-phase responses include characteristic activation of hepatic protein metabolism and synthesis of specific hepatic proteins (e.g., C-reactive protein). This protein can easily be detected and, along with fever, serves as an indicator of inflammatory disease (71). Elective surgery is usually cancelled in febrile patients. However, febrile patients may require urgent surgery for unrelated reasons or to relieve the cause of fever.

4.5.2. Intraoperative Fever

Intraoperative fever is nonetheless relatively rare considering how frequently pyrogenic etiologies are likely to be present during surgery and how common fever is after surgery. This low incidence of intraoperative fever occurs as a consequence of the general impairment of thermoregulation by anesthesia. Anesthesia has the potential to decrease core body temperature during surgery in febrile patients. A study in human volunteers indicated that the volatile anesthetic desflurane reduces the febrile response and peak core temperature following pyrogen administration in a dose-dependant fashion (70). In fact one MAC (minimum alveolar concentration) of desflurane essentially obliterated fever but did not affect the plasma concentration of peripheral cytokines induced by interleukin-2. The primary mechanism of fever reduction during general anesthesia thus seems to be a central action of volatile anesthetics. In contrast, a peripherally mediated inhibition via reduced release of pyrogenic cytokines does not appear to play a major role in the reduction of intraoperative fever.

A study revealed that the range between the sweating and the vasoconstriction threshold was significantly lower during the combination of anesthesia with fever compared with anesthesia alone, suggesting an active role of the sympathetic nervous system (25). Thus, fever-induced activation of the sympathetic nervous system may contribute by compensating for a fraction of the anesthetic-induced thermoregulatory impairment.

Paralysis is often used during surgery to facilitate access to the surgical field. Paralytic agents may contribute to the relative rarity of intraoperative fever by preventing shivering and the associated increase in metabolic heat production. In fact, in volunteers paralysis prevents shivering from increasing the metabolic rate (72). However, peak core temperatures during paralysis were only minimally reduced as compared with a non-paralyzed group, suggesting that shivering is not a key factor for intraoperative fever. In contrast, vasoconstriction plays the major role in maintaining fever (72).

Apart from volatile anesthetics, intravenous agents are used to induce and maintain general anesthesia. Although the interaction of fever with intravenous anesthetics has not been tested formally, it is conceivable that a similar reduction of the fever magnitude might be observed. Another major component of balanced anesthesia is opioids. Opioids were also tested for their potential to decrease febrile temperatures during anesthesia. Both fentanyl and alfentanil in sub-anesthetic doses reduce induced fever during anesthesia by half a degree centigrade (73, 74). Neither fentanyl nor alfentanil reduces plasma concentration of cytokines after induced fever. Thus, the effect of opioids on the inhibition of fever appears to be mediated centrally rather than peripherally. Taken together, these findings suggest that anesthetic-induced inhibition of thermoregulatory responses to fever contributes to the relative rarity of fever during surgery. This low incidence results in part from dose-dependent inhibition of fever by volatile anesthetics, opioids and, to a minor degree, paralytic agents inhibiting shivering.

4.5.3. Postoperative fever

In contrast to intraoperative fever, postoperative fever is common and continues to be a major problem. Early postoperative fever may just be a manifestation of perioperative stress (75). Postoperative fever may also be part of the acute inflammatory response of the immune system to the surgical procedure (76). The anesthetic technique used during surgery appears to have little effect on postoperative fever (77). However, many drugs used in the postoperative period such as non-steroidal anti-inflammatory drugs (NSAIDs), sedatives, and opioids have immunomodulatory effects and may affect postoperative thermoregulation.

Postoperative fever is a common phenomenon in surgical patients. The incidence of fever varies with type and duration of surgery, patient's age, surgical site and preoperative inflammation (78-80). Regardless of its onset, fever is considered an early sign of infection in surgical patients. This makes sequential temperature measurements indispensable in the postoperative period. Roughly 25% of patients undergoing abdominal, and non-cardiac thoracic procedures, show a fever in the first 24 hours after surgery. However in a study on postoperative fever postoperative temperature was generally elevated in the patient population, but only one patient developed a postoperative infection. This study also showed that the elevated temperature was associated with elevated levels of IL-6, but it did not correlate with the leukocyte count (77). This observation confirmed the concept that early postoperative fever may be caused by a normal inflammatory response induced by surgical stress rather than a postoperative infection. However, if core temperature remains elevated for an extended period or develops at a later postoperative stage, infection is usually the cause and should prompt fever workup (81). Wound infections are responsible for many such episodes of fever, although numerous other etiologies contribute. Initial diagnosis should thus focus on determining the etiology of fever. Once that is established, treatment can focus on the specific cause.

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