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Body Temperature Changes under Anesthesia

Essay

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List of Abbreviations

ACC	American College of Cardiology
AHA	American Heart Association
ASA	American Society of Anesthesiologists
ATP	Adenosine triphosphate
BMI	Body mass index
BMR	Basal metabolic rate
°C	Degree Celsius
CaCl2	Calcium chloride
CK	Creatine kinase
CNS	Central nervous system
COX-2	Cyclooxygenase 2
DIC	Disseminated intravascular coagulation
DMH	Dorsomedial hypothalamus
ECG	Electrocardiogram
ETCO2	End tidal carbon dioxide
°F	Degree Fahrenheit
GA	General anesthesia
ICU	Intensive care unit
IL-1	Interleukin-1
K	Kelvin
Kcal	Kilocalorie
LBP	Lipopolysaccharide-binding protein
LPS	Lipopolysaccharides
MAOIs	Monoamine oxidase inhibitors
MH	Malignant hyperthermia
NIBP	Non invasive blood pressure
NMS	Neuroleptic malignant syndrome
PACU	Postoperative anesthesia care unit
PLA2	Phospholipase A2
POA	Preoptic area

List of Abbreviations

PVN	Paraventricular nucleus
rRPa	rostral raphe pallidus nucleus in the medulla oblongata
SaO2	Oxygen saturation
SSIs	Surgical Site Infections
SSRIs	Selective serotonin reuptake inhibitors
T	Temperature
TNF	Tumor necrosis factor
TRH	Thyrotropin-releasing hormone
TSH	Thyroid-stimulating hormone

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Introduction:

Normal human body temperature, also known as normothermia or euthermia, is a concept that depends upon the place in the body at which the measurement is made, and the time of day and level of activity of the person. There is no single number that represents a normal or healthy temperature for all people under all circumstances using any place of measurement ***(Elert & Glenn 2005).***

Different parts of the body have different temperatures. Rectal and vaginal measurements, or measurements taken directly inside the body cavity, are typically slightly higher than oral measurements, and oral measurements are somewhat higher than skin temperature. The commonly accepted average core body temperature (taken internally) is 37.5 °C (99.5 °F). The typical oral (under the tongue) measurement is slightly cooler, at 37.0±0.5 °C, or 98.6±0.9 °F ***(Mackowiak et al, 1992).***

Normally, the body's core temperature represents a homeostatic balance between heat generation due to metabolic processes, and heat loss through conduction, convection, evaporation, respiration, and radiation ***(Wong, 1983).***

Anesthesia may induce impairment of this balance and disturb the thermoregulatory control resulting in either hypothermia or hyperthermia.

Inadvertent hypothermia is one of the most commonly and frequently reported complications in surgical patients which is neither planned nor desired. Many factors may be involved in the occurrence of intraoperative hypothermia e.g. prolonged fasting, insufficient clothing, prolonged surgeries, cold operating rooms and extremes of ages ***(McNeil, 1998).***

Hypothermia produces numerous adverse effects and consequences on the body which include: altered cardiac performance, coagulopathy, altered action of commonly used anesthetic medications, increased incidence of wound infection, delayed emergence from anesthesia and increase rate of mortality ***(Tander et al, 2005).***

On the other hand, intraoperative hyperthermia may occur due to incompatible blood transfusion, trauma, some drugs e.g. selective serotonin reuptake inhibitors (SSRIs), monoamine oxidase inhibitors (MAOIs) and amphetamines, endocrinal causes e.g. thyrotoxicosis and pheochromocytoma, connective tissue disorders,

neuroleptic malignant syndrome and malignant hyperthermia ***(Fauci et al, 2008).***

Malignant hyperthermia is a rare life-threatening disease passed down through families that causes a fast rise in body temperature (fever) and severe muscle contractions when the affected person gets general anesthesia ***(Litman & Rosenberg, 2005)***.

Hyperthermia may lead to hypotension and dehydration secondary to peripheral vasodilatation and sweating. It also may lead to seizures, CNS damage and even death, ***(Fauci et al, 2008)***

So, it is important to maintain intraoperative normothermia to avoid such complications and improve patients` outcomes to decrease the incidence of morbidity and mortality ***(Katherine et al, 2008)***.

Humans are warm-blooded animals or homeotherms. Like other mammals, humans are able to regulate their internal body temperatures within a narrow range near 37°C, despite wide variations in environmental temperature. In contrast, internal body temperatures of poikilotherms, or cold-blooded animals, are governed by environmental temperature. The range of temperatures that living cells and tissues can tolerate without harm extends from just above freezing to nearly 45 °C far wider than the limits within which homeotherms regulate body temperature ***(Frank, 2009)***.

Tissue temperature is important for two reasons. First, temperature extremes injure tissue directly. High temperatures alter the three-dimensional structure of protein molecules, even though the sequence of amino acids is unchanged. Such alteration of protein structure is called denaturation. A familiar example of denaturation by heat is the coagulation of albumin in the white of a cooked egg. Because the biological activity of a protein molecule depends on its configuration and charge distribution, denaturation inactivates a cell's proteins and injures or kills the cell. Injury occurs at tissue temperatures higher than about 45°C, which is also the point at which heating the skin becomes painful. The severity of injury depends on the

temperature to which the tissue is heated and its duration. Cold also can injure tissues. As a water-based solution freezes, ice crystals consisting of pure water form, so that all dissolved substances in the solution are left in the unfrozen liquid. Therefore, as more ice forms, the remaining liquid becomes more and more concentrated. Freezing damages cells through two mechanisms. First, ice crystals mechanically injure the cell. The increase in solute concentration of the cytoplasm as ice forms denatures the proteins by removing their water of hydration, increasing the ionic strength of the cytoplasm and causing other changes in the physicochemical environment in the cytoplasm ***(Rodney & David, 2012).***

Second, temperature changes profoundly alter biological function through specific effects on such specialized functions as electrochemical properties and fluidity of cell membranes and through a general effect on most chemical reaction rates. In the physiological temperature range, most reaction rates vary approximately as an exponential function of temperature (T); increasing T by 10°C increases the reaction rate by a factor of two to three. For any particular reaction, the ratio of the rates at two temperatures 10°C apart is called the Q_{10} for that reaction, and the effect of temperature on reaction rate is called the Q_{10} effect. The

notion of Q_{10} may be generalized to apply to a group of reactions that have some measurable overall effect (such as O_2 consumption) in common and are, thus, thought of as comprising a physiological process. The Q_{10} effect is clinically important in managing patients who have high fevers and are receiving fluid and nutrition intravenously. A commonly used rule is that a patient's fluid and calorie needs are increased 13% above normal for each 1°C of fever ***(Rodney & David, 2012).***

The sluggishness of a reptile that comes out of its burrow in the morning chill and becomes active only after being warmed by the sun illustrates the profound effect of temperature on biochemical reaction rates. Homeotherms avoid such a dependence of metabolic rate on environmental temperature by regulating their internal body temperatures within a narrow range. A disadvantage of homeothermy is that, in most homeotherms, certain vital processes cannot function at low levels of body temperature that poikilotherms tolerate easily. For example, shipwreck victims immersed in cold water die of respiratory or circulatory failure (through disruption of the electrochemical activity of the brainstem or heart) at body temperatures of about 25°C, even though such a

temperature produces no direct tissue injury and fish thrive in the same water ***(Frank, 2009).***

Body Temperature and Heat Transfer:

The body is divided into a warm internal core and a cooler outer shell (figure 1). Because the environment greatly influences the temperature of the shell, its temperature is not regulated within narrow limits as is the internal body temperature. This is true despite the thermoregulatory responses that strongly affect the temperature of the shell, especially its outermost layer, the skin. The thickness of the shell depends on the thermal environment and the body's need to conserve heat. In a warm environment, the shell may be less than 1 cm thick, but in a subject conserving heat in a cold environment, it may extend several centimeters below the skin. The regulated internal body temperature is the temperature of the vital organs inside the head and trunk which, together with a variable amount of other tissue, comprise the warm internal core ***(Rodney & David, 2012).***

Heat is produced in all tissues of the body but is lost to the environment only from tissues in contact with the environment predominantly from the skin and, to a lesser degree, from the respiratory tract ***(Rodney & David, 2012).***