Hyperthermia in ICU patients

An Essay

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بسم الله الرحمن الرحيم

قالوا

سبحانك لا علم لنا
إلا ما علمتنا إنك أنت
العليم الحكيم

صدق الله العظيم

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List of Abbreviations

CNS	: Central nervous system
ICU	: Intensive care unit
IEDs	: Improvised Explosive Devices
IL-1	: Interleukin-1
IPA	: Intra-pulmonary artery
ITTs	: Infrared Tympanic Thermometers
MAO	: Monoamine oxidase
MDMA	: Methylendioxymeth- amphetamine
MH	: Malignant hyperthermia
NMS	: Neuroleptic malignant syndrome
PCP	: Pentachlorphenol
PPE	: Personal protective equipment
SSRIs	: Selective serotonin reuptake inhibitors
Tc	: Core Temperature
TCA	: Tricyclic antidepressant

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Introduction

Normal body temperature is generally considered to be 37.0°C (98.6°F). In healthy individuals, this temperature varies by 0.5 to 1.0°C, according to circadian rhythm and menstrual cycle. With heavy exercise, temperature can rise by 2 to 3°C. Whereas many biological processes can alter body temperature, a variety of environmental forces in an ICU can also alter temperature, such as specialized mattresses, hot lights, air conditioning, cardiopulmonary bypass, peritoneal lavage, dialysis, and continuous hemofiltration **(Waterhouse et al., 2004)**.

Although an elevated body temperature usually represents a fever in the vast majority of patients, there are a few instances in which an elevated temperature is secondary to hyperthermia: heat stroke syndromes, certain metabolic diseases (hyperthyroidism), and use of drugs that interfere with thermoregulation. Both conditions result in an elevation of body temperature, but they differ physiologically. With fever, thermoregulatory mechanisms remain intact, but the hypothalamic thermal set point is raised by exposure to endogenous pyrogens, leading to behavioral and physiologic responses to elevate body temperature. In contrast to fever, during hyperthermia, the setting of the thermoregulatory center remains unchanged at normothermic levels, whereas body temperature increases in an uncontrolled fashion and overrides the ability to lose heat **(Bhanushali and Tuite, 2004)**.

Uncontrolled hyperthermia is independently associated with increased morbidity and mortality. Hyperthermia may cause rhabdomyolysis, liver failure, disseminated intravascular coagulation and multi-organ failure. It accentuates excitotoxic neurotransmitter release, increases production of oxygen free radical species, accelerates cytoskeleton protein degradation, and increases the risk of seizures. A recent publication demonstrates a nearly 30% mortality rate from all heat-related illness presenting to the emergency department; thus, early recognition and management of hyperthermic reactions is essential **(LoVecchio et al., 2007).**

Aim of the Essay

The aim of the essay is to throw a light on heat regulation in normal body and hyperthermia in ICU patients concerning its difference from fever, causes, pathophysiology, diagnosis, prevention and its management in ICU patients.

Heat Regulation in Normal Body

Thermoregulation is the ability of an organism to keep its body temperature within certain boundaries, even when the surrounding temperature is very different. A thermoconforming organism, by contrast, simply adopts the surrounding temperature as its own body temperature, thus avoiding the need for internal thermoregulation. The internal thermoregulation process is one aspect of homeostasis: a state of dynamic stability in an organism's internal conditions, maintained far from thermal equilibrium with its environment **(Kanosue et al., 2009).**

If the body is unable to maintain a normal temperature and it increases significantly above normal, a condition known as hyperthermia occurs. For humans, this occurs when the body is exposed to constant temperatures of approximately 55 °C (131 °F), and with prolonged exposure (longer than a few hours) at this temperature and up to around 75 °C (167 °F) death is almost inevitable. Humans may also experience lethal hyperthermia when the wet bulb temperature is sustained above 35 °C (95 °F) for six hours **(Kanosue et al., 2009)**.

The opposite condition, when body temperature decreases below normal levels, is known as hypothermia. It results when the homeostatic control mechanisms of heat within the body malfunction, causing the body to lose heat faster than producing it. Normal body temperature is around 37 °C (99 °F), and hypothermia sets in when the core body temperature gets lower than 35 °C (95 °F). Usually caused by prolonged exposure to cold temperatures, hypothermia is usually treated by methods that attempt to raise the body temperature back to a normal range **(Kanosue et al., 2009)**.

Normal human temperature:

Previously, average oral temperature for healthy adults had been considered 37.0 °C (98.6 °F), while normal ranges are 36.1 °C (97.0 °F) to 37.8 °C (100.0 °F). In Poland and Russia, the temperature had been measured axillary. 36.6 °C was considered "ideal" temperature in these countries, while normal ranges are 36 °C to 36.9 °C. Recent studies suggest that the average temperature for healthy adults is 36.8 °C (98.2 °F) (same result in three different studies) **(Kanosue et al., 2009)**.

Variations of body temperature:

Normal human body temperature (normothermia or euthermia) depends upon the place in the body at which the measurement is made, 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 **(Laupland, 2009)**.

Figure (1) revealed that Body temperature normally fluctuates over the day, with the lowest levels around 4 a.m. and the highest in the late afternoon, between 4:00 and 6:00 p.m. (assuming the person sleeps at night and stays awake during the day) **(Mackowiak et al., 1992)**.

Therefore, an oral temperature of 37.3°C would, strictly speaking, be a normal, healthy temperature in the afternoon but not in the early morning. An individual's body temperature typically changes by about 0.5 °C between its highest and lowest points each day **(Mackowiak et al., 1992)**.

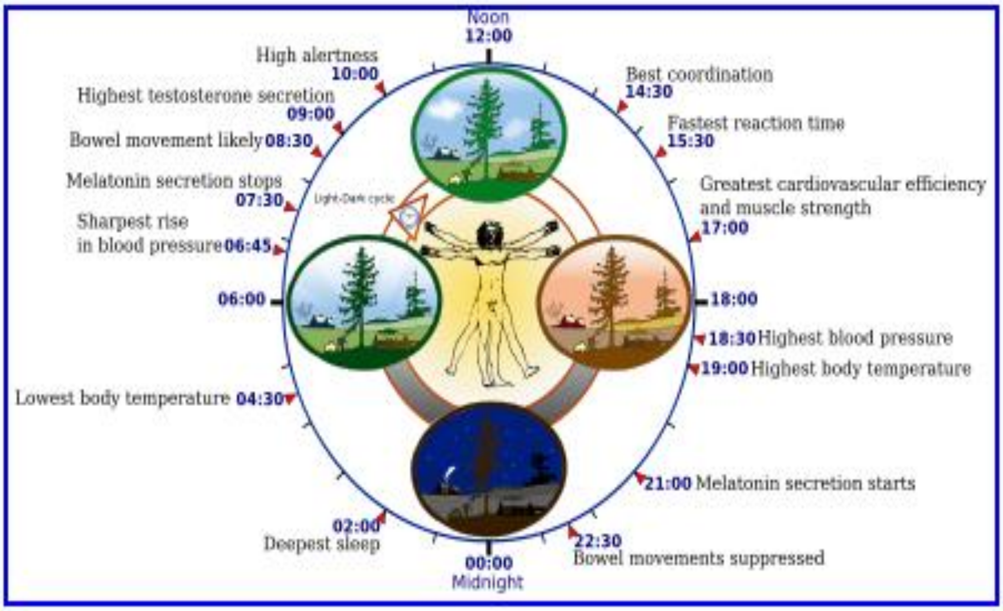

Figure (1): Variations in body temperature are part of the circadian rhythm **(Laupland, 2009).**

Temperature also varies with the change of seasons during each year. This pattern is called **a circannual rhythm**. Studies of seasonal variations have produced inconsistent results. People living in different climates may have different seasonal patterns. Increased physical fitness increases the amount of daily variation in temperature **(Kelly, 2008)**.

Variations due to women's menstrual cycles:

Body temperature is sensitive to many hormones, so women have a temperature rhythm that varies with the menstrual cycle, (a circamensal rhythm). A woman's basal body temperature rises sharply after ovulation, as estrogen production decreases and progesterone increases **(Marx, 2006)**.

During the follicular phase (which lasts from the first day of menstruation until the day of ovulation), the average basal body temperature in women ranges from 36.45 to 36.7 °C (97.6 to 98.1 °F). Within 24 hours of ovulation, women experience an elevation of 0.15–0.45 °C (0.2–0.9 °F) due to the increased metabolic rate caused by sharply elevated levels of progesterone. The basal body temperature ranges between 36.7–37.3 °C (98.1–99.2 °F) throughout the luteal phase, and drops down to pre-ovulatory levels within a few days of