MEASUREMENT OF BODY TEMPERATURE AND ITS SIGNIFICANCE TO THE ANAESTHESIST

THESIS

Submitted in Partial Fulfillment
for Master Degree in Anaesthesiology

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1986

بسم الله الرحمن الرحيم

وقل رب زدني علما

صدق الله العظيم

بسم الله الرحمن الرحيم

ACKNOWLEDGEMENT

I am greatly indebted to Professor Doctor Kadry Merham, Chairman of Anaesthesiology departement,Ain-Shams University, for his faithfull supervision,guidance and encouragement throughout the accomplishment of this work.

I also acknowledge with profound gratitude the cooperative collaboration,meticulous supervision of Doctor Sherif Moustafa,Assistant Professor of Anaesthesia,Ain-Shams University.

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* TEMPERATURE REGULATION *

Animals are classified into 2 main groups according to their capacity to regulate their body temperature. (Adolph,1951).

A) Poikilothermic (Cold blooded)animals :-

Their body temperature fluctuates over a considerable range,varying with that of the environment;e.g.amphibians.

B) Homeothermic (Warm blooded)animals :-

Where a group of reflex responses integrated in the hypothalamus operate,to maintain body temperature within a narrow range inspite of wide fluctuations in environmental temperature. Man is a homeothermic animal.(Hull & Segall,1965).

* Normal body temperature *

Various parts of the body are at different temperatures,and the magnitude of the temperature difference between the parts,varies with the environmental temperature. The extremities are generally cooler than the rest of the body.The skin temperature vary considerably,according to pos--ition,state of local circulation,sweating,clothing,climatic conditions,etc ...

Foregger (1943),showed that the magnitude of the changes in skin temperature depends on the ambient temperature. Beneath adequate clothing,the trunk skin temperature is usua--lly about 33 oC.

The rectal temperature is a representative of the tempe--rature of the core of the body and varies least with changes in environmental temperature.Spealman(1943),however,believes that temperature taken within the oesophagus,is possibly a more reliable index of deep body temperature.The rectal temp--erature is less useful because it lags by at least 1-2 oC, behind the oesophageal temperature,both during the cooling and rewarming process.Further,if there is any interference with the blood supply of the lower part of the body as may occur for example during operations for abdominal aneurysms, the rectal temperature figures will be misleading.

The normal human core temperature undergoes a regular diurnal fluctuation of 0.5-0.7 oC.(Gannong,1977).It is lowest during sleep,slightly higher in the awake,but relaxed state, and appears to be largely related to eating,and perhaps to activity,since it can be reduced by fasting.(Iampetro et al., 1957).

In women,there is an additional monthly cycle of temperature variation,characterized by a change in basal temperature at the time of ovulation,which is related to pregnenolone,pregnandiol,and other 5-B steroids.(Kappas,et al.,1959).

Oral temperature is normally 0.5 oC lower than the rectal temperature,but it is affected by many factors,including:ingestion of hot or cold fluids,gum-chewing smoking and mouth breathing.In normal young adults,the normal oral temperature on the average is 36.7 oC,with a standard deviation of 0.2 oC.(Gannong,1977).

Body temperature also rises slightly during emotional excitement,probably due to unconscious tensing of the muscles (Renbourn,1960).

During exercise,the heat produced by muscular contraction accumulates in the body,and rectal temperature rises markedly.This rise is due in part to the inability of the heat-dissipating mechanisms to handle the greatly increased amount of heat produced.(Snell,1954).

Regulation of body temperature in man (Homeostasis of central temperature)

Normally,in homeothermic animals,e.g.in man,the body temperature is the result of a fine balance between heat production and heat loss,and there is an evidence now for man as well as for animals that there are two regulating systems (Cranston,1966).The first is a reflex whose afferents arise from the skin where there are skin receptors responding to heating and cooling.(Hensel,1961).The second system is central temperature receptors,existing in the hypothalamus as evidenced by the work of Pickering (1932).These receptors in the hypothalamus,respond to local temperature rises of 0.1-0.2 oC,leading to skin vasodilatation,sweating or increased respiration ,whereas cooling causes vasoconstriction and shivering.(Magoun et al.,1938 ; Folkow, et al.,1949).

* Role of skin and central receptor systems :-

Temperature regulation is entirely controlled by the central temperature regulating mechanisms,when the skin temperature exeeds 33oC.(Benzinger,1962).

It is probable that stimuli from the skin and central receptors summate.Skin receptors are more important when people are exposed to environmental temperature changes,particularly if these are rapid.Central receptors compensate for changes in endogenous heat production and prevent over compensation by the skin reflexes.(Cranston,1966).

Stolwijk and Hardy (1966),had deviced a mathematical formula that combines these two kinds of signals.According to their concept,the body does not respond to a change in the skin temperature,when there is no central changes,and likewise,does not respond to central change in the absence of peripheral deviation.

The hypothalamus serves as a thermostat for the rest of the body.(Benzinger,1969).In a sense,it utilizes the rest of the body to stabilize its own temperature,cooling the body when it becomes warm,and retaining heat in the body,and stimulating heat production when it is chilled.

Two hypothalamic centers of thermoregulation have been identified: anterior and posterior hypothalamic centers.

The anterior center is concerned for heat loss,througgh the reflex responses activated by warmth.These include respiratory heat-loss responses and vaso-motor heat loss responses.(Folkow,et al.,1949).Thus stimulation of the anterior hypothalamus,causes cutaneous vasodilatation and sweating,and lesions in this region causes hyperthermia.(Gannong,1977).

The posterior center concerned with heat production through the reflex responses activated by cold.The posterior center is a heat-maintenance center,relays cold receptor impulses,transducing these into shivering and increased heat production.Stimulation of the posterior hypothalamus causes shivering and the body temperature of animals with posterior hypothalamic lesions falls towards that of the environment.(Gannong,1977).

An inter-relation exists between the two centers-anterior inhibiting posterior.

* Transmitter substances :-

Feldberg and Myers (1963),suggested that normal body temperature is maintained by a delicate balance in the release of adrenaline,noradrenaline and 5-hydroxy-tryptamine in the hypothalamus.There is some evidence that serotonin (5-hydroxy-tryptamine) is a synaptic mediator in the centers controlling the mechanisms activated by cold,and norepinephrine may play a similar role in those activated by heat.

* The role of endocrine glands in thermoregulation :-

The thyroid and adrenal glands,play significant roles in the regulation of body temperature.Cannon (1932),observed that exposure to cold causes an increase in the rate of the denervated heart of a cat,as a result of epinephrine secretion.This hormone exerts a calorigenic effect which is immediate and of short duration. A less immediate and much more prolonged increase in heat production is brough about by stimulation of the thyroid gland.

* Control of heat production :-

Heat production is the result of metabolic activities.

The amount of energy liberated per unit of time is the metabolic rate.(Gannong,1977).

So,energy output=external work + energy storage + heat.

The rate of heat production under basal conditions is called the basal metabolic rate,which is 1700 calories/day in the male and 1500 calories/day in the females.

The major source of heat in the contraction of skeletal muscles in the form of muscle tone,exercise and shivering. This appears to be the only mechanism whereby heat production can be increased rapidly.(Johnson,et al.,1963).

Muscle relaxants reduce or abolish muscle acitivity and reduce heat production.(Farman,1962).

Ingestion of food,increases heat production,because of the specific dynamic action of food.(Gannong,1977).

Heat production can be varied in the absence of food intake or muscle exertion by endocrine mechanism.Epinephrine and norepinephrine produce a rapid,but short-lived increase in heat production(Egdahl and Richards,1956),thyroxine causes a slowly developing but prolonged increase.(Brown-Grant,1956)

* Heat gain from the environment :-

The body can take in heat from objects by direct radiation,e.g. from the sun or from the operating lights.When is in hot environment,heat is transmitted to it by conduction,convection and radiation and adds to its heat load (Gannong,1977)

* Control of heat loss :-

The processes by which heat is lost from the body when the environmental temperature is below body temperature,occur through 3 channels;skin,repiratory tract and excreta.

Heat is lost from the skin by physical means and physio--logical means.The physical means include radiation,conducti--on and convection.When an individual is in a cold environment,he loses heat by conduction to the air around him and by radiation to cool objects in the vicinity.

Radiant heat loss is largely a function of skin blood flow,so that one may consider regulation of skin blood flow as a fine adjustement mechanism for controlling temperature,while shivering and sweating are coarse adjustement.The rate at which heat is transferred from the deep tissues to the skin is called the tissue conductance,(Gannong,1977),which depends on the skin blood flow,i.e. whether the cutaneous vessels are dilated or constricted.

Physiological means,i.e. vaporization of water through sweating and insensible water loss.Sweat is secreted by the sweat glands,but insensible loss is a transudate through the epidermis.In the conscious subject,sweating occurs when an increase in heat loss is required to maintain a normal body temperature,but it can also be provoked by emotional stimuli, asphyxia and hypoxia.

The sweat glands are innervated by cholinergic fibres of the sympathetic system,and sweating in these circumstances may merely reflect increased sympathetic activity.(Churchill-Davidson,1972).

When sweat secretion is increased,the degree to which the sweat vaporises depends upon the humidity of the environment.Evaporization of sweat from the body surface results in loss of heat,because of the consumption of latent heat of evaporation.In a cool environment,anaesthesized patients are unlikely to lose heat from sweating,especially if their body core temperature has decreased.(Benzinger,1969) In hot ambient conditions,sweating produces a more significant heat loss than the other physical methods.(Fox,1974).The thermal efficiency of sweating depends on the ambient relative humidity and it is ineffective if the air in direct contact with the skin is fully saturated with water.

The insensible water loss amounts to 50 ml/hour in man.

Vaporization of one gram of water removes about 0.6 Kcal of heat.(Gannong,1977).So,vaporization of one liter of water from the skin or lung is equivalent to heat loss of 580 Kcal. Heat loss via the excreta is small.

Only recently has the importance of heat loss via the respiratory tract has been appreciated.Vale(1973) has shown that this heat loss is due to heating of dry gases introduced into the airway at ambient temperature or lower.This amounts