Body Temperature

- Normal body temperature of adult human
  \[37 \pm 0.6 \, ^\circ\text{C}\]

Body Temperature Measurement

Methods for body temperature measurement

1. Under the tongue
2. In the ear canal (tympanic membrane)
3. In the rectum
4. Axilla
5. Infrared pyrography
6. Skin thermister thermometer

Sources Of Body Heat Production

- Resting
  - Internal organ e.g. heart, liver

- Exercise
  - Muscle

Oral Route

- Site
  - posterior sublingual pockets in the oral cavity for 3 mins

- The accurate measurement of temperature affected by
  - eating
  - drinking
  - smoking
Axillary Route

- Site
  - Placed centrally in the patient's axilla
- A temperature variation of +/- 0.5 °C has been found between the left and right arm

Rectal Route

- Site
  - Measured from a thermometer inserted 3-4 cm into the anus.
- More accurate than oral or axilla measurements.
- Cons
  - Adults
    - invasive, uncomfortable, embarrassing and unnecessary
  - Infants
    - suffer rectal ulceration and perforation caused by the thermometer
    - Imperforate anus

Tympanic Route

- Site
  - measured by inserting a probe into the auditory canal.
- by measuring the amount of infrared energy given off by the tympanic membrane.
- clean, quick and painless

Body Core Temperature

- The mean values were
  - 36.4 °C oral
  - 36.9 °C rectal
  - 36.5 °C tympanic
  - 36.3 °C axillary

Factor Determine Body Temperature

Depending on
1. Time of day
   - circadian rhythm / diurnal variation
2. Menstrual cycle
3. Physical activity / emotion
4. Age

Circadian Body Temperature Rhythm

- Highest 4.00-6.00 p.m.
- Lowest 4.00-6.00 a.m.
- Independent of Sleep-wake cycle
Basal Body Temperature and Menstrual Cycle

Age
- Newborns
  - No shivering
  - No sweat
  - High surface-to-mass ratio
  - Brown adipose tissue
- Aging
  - Deficit heat and cold sensing
  - Reduced ability to generate heat
  - Sweat gland atrophy
  - Less cardiovascular reserve
  - More susceptible to core temperature fluctuation

Rate of Heat Production
- Linked to
  - Rate of metabolism
  - Shivering thermogenesis
  - Brown adipose tissue
  - (non-shivering thermogenesis)

Metabolism
- Metabolism = Catabolism + Anabolism
  - Catabolism
    - Breakdown of larger molecule to get smaller molecule + energy
  - Anabolism
    - Building up of complex molecule

Shivering Thermogenesis

Brown Adipose Tissue
- Mainly in babies
- High mitochondria content
- Create more heat than other cells
- Stimulate by sympathetic nervous system

Brown adipose tissue
White adipose tissue
Heat Distribution

Counter Current Heat Exchange

- Purposed
  - Preserved heat in cold environment
  - Transferred heat in hot environment

Modes of Heat Transfer

Evaporation

- Convection, conduction and radiation become heat gain when ambient temperature > 35 °C
- Evaporation – independent of the temperature
  - limited by vapor pressure
  - important during exercise

Method of Evaporation

- Insensible perspiration
  - 400-700 ml/day
- Sweating
  - Osmotic pressure < plasma (less Na)
    - Hypotonic, hypoosmolar
    - Maximum rate up to 2 liters/hr
- Panting

Perspiring = to emit matter through the skin
Body Heat Generation

- Metabolism
- Convection
- Conduction
- Radiation
- Evaporation

Thermoregulatory System

- Core temperature
- Skin temperature
- Central temperature receptors (hypothalamus)
- Skin temperature receptors (hypothalamus)
- Hypothalamic set-point temperature
- Skin vasoconstrictor activity
- Shivering
- Sweat gland

Cold Response

- Decrease heat loss
- Increase heat production
- Cutaneous vasoconstriction
- Piloerection
- Postural changes
- Increase stress hormone (epinephrine)

Warmth Response

- Increase heat loss
- Cutaneous vasodilation
- Sweating
- Postural changes
- Decrease heat production
- Increase muscle tone
- Increase appetite, metabolism
- Decrease stress hormone

Core Temperature

- Low
- High
Skin Blood Flow

Goose Bumps

Body Core Temperature

Abnormal Body Temperature

- Hyperthermia
  - Body temperature > 38 °C
  - Prolonged heat exposure
  - High ambient humidity + physical activity
  - Febrile convulsion, Neural damage

- Hypothermia
  - Body temperature < 36.1 °C
  - Prolonged immersion in cold water
  - Frost bite, Ventricular fibrillation

Fever (Pyrexia)

- A state that Body temperature set point > 37 °C (Body temp > 37.8 °C, orally)
• Fever

- Increased heart rate
- Increased respiration
- Increased sweating
- Febrile convulsion
- Neuronal damage

• Mechanism

- Higher set-point temperature (Hypothalamus level) by pyrogen (endogenous & exogenous)

Fever

Stage of fever
1. Rising phase (ไขขึ้น)
2. Steady phase (ไขทรง)
3. Defervescence (ไขลดลง)

Rising phase
1. Sympathetic activation — reduction of heat loss
   1. Arteriolar constriction
   2. Superficial venoconstriction
2. Shivering — increase heat production
3. Postural changes — reduction of heat loss
Fever

Steady phase
1. Body temperature at steady temperature
2. Heat loss = Heat production
3. Higher metabolism rate

Defervescence
1. Set-point temperature set to normal temperature
2. Body temperature gradually decrease by
   1. Sweating
   2. Vasodilatation

Fever

• การรักษาไข้
  1. กักจัดสาเหตุของไข้ เช่น การถ่ายเชื้อ
  2. ให้น้ำทดแทนจากการเสียเหงื่อ
  3. เพลียดเสียวร่างกายผูกมัดหรือบีบเบียด
  4. ให้ยาลดไข้ (paracetamol, NSAIDS)

Hyperthermia
(Normal thermostat set point 37.0)

• Exercise
• Heat illness
• Malignant hyperthermia
  – Genetics disease
• Endocrine hyperthermia
  – Hyperthyroidism
  – Pheochromocytoma crisis

Heat Illness

Heat Syncope (ลมแดด)
1. Prolong Immobilization (no muscle contraction)
2. Peripheral vasodilation (heat transfer)
3. Resulting in reduced venous return
4. Syncope
5. การนอนจะทำให้เลือดกลับสมองได้ดี
Heat Exhaustion

1. Exertion in hot condition
2. Excessive sweating
3. Hypovolemia
4. Hypotension

Treatment
1. ให้นอนราบและให้น้ำเกลือทดแทนเหงื่อที่เสียไป

Heat Stroke

– The person's cooling system has stopped working (hypothalamus level)
– The internal temperature has risen to the point where brain damage (temperature 40.5 °C (105°F)).

Heat Stroke

• Classification
  – The classic form occurs in people whose cooling mechanisms are impaired eg. infant, elderly.
  – The exertional form occurs in previously healthy people who are undergoing strenuous activity in a hot environment.

Heat Stroke

• Symptoms
  – Unconscious or markedly abnormal mental status
  – Flushed, hot, and dry skin
  – Dizziness, confusion, or delirium
  – Slightly elevated blood pressure at first that falls later
  – Hyperventilating
  – Core temperature of 40.5 °C or more