HEAT STROKE
PHYSIOLOGY OF THERMO-REGULATION
Body temperature is maintained in its normal level by the balance between heat production and heat loss.

The range of normal body temp. is very narrow, about 1 degree \[ 36.5 - 37.5 \].

It is controlled by the heat regulating centre in the hypothalamus.
Sources of body heat?

- Normal basal metabolism [BMR]
- Activity of different organs [heart, GIT., diaphragm,..]
- Usual daily activities like daily work, walking, eating, exercise ext.
- Absorption of heat from the surrounding atmosphere by: conduction, radiation, and convection.
Sources of body heat (con):

- Absorption of heat from the surrounding atmosphere by:
  1. **Conduction**: [direct contact with hot object]
  2. **Radiation**: by transformation of heat to electro magnetic waves like sun rays.
  3. **Convection**: contact with gas or liquid with different temperature
Ways of heat LOSS

- In expired air.
- In body excreta [urine, stool, tears, sweat...].
- Convection: [Contact with cold environment]
- Radiation: [responsible for loss of about 65% of body heat in normal weather at rest]
- conduction.
- Evaporation of sweat.
Heat content of the body

Heat gain

Daily variation

Heat loss

BMR
Muscular activity
Hormones
Dietary-induced thermogenesis
Postural changes
Environment

Radiation
Conduction
Convection
Evaporation
Heat regulating center:

- A highly specialized sensitive cells present in the anterior hypothalamus adjusted to normal body temp [36 -37.8] by means of set-point.
Heat regulating centre:

- The centre gets information about the body temp. by means of thermo-sensors (specialized cells located in the viscera, skin, spinal cord, hypothalamus).

- These sensors send continuous impulses to the anterior hypothalamus through afferent fibers passing in the spinal cord and brain stem.
Heat regulating centre

The temp is then compared with that of set point.

1. **IF LESS THAN IT**, heat production mechanisms are initiated.

2. **IF MORE THAN IT**, heat loss mechanisms are initiated.

- A core temperature greater than 41°C or less than 34°C usually indicates that the body’s ability to thermoregulate is impaired.
Heat regulating centre

Heat production & heat loss mechanisms are stimulated by orders: from the posterior hypothalamus to:

- endocrinal system
- musculoskeletal system
- autonomic nervous systems.
Mechanism of heat loss:

Through reflexes from the hypothalamus to:

1. **Autonomic n. system** leading to vasodilatation of the peripheral blood vessels & sweating.[about 8 liters of blood reaches the peripheral circulation each minute]

2. **Endocrinal system** leading to decreased secretion of thyroxin & catecholamine and increased secretion of anti-diuretic hormone & aldosterone.

3. **Arrector** pili muscles relaxing.
HEAT ILLNESS

- Heat Cramps
- Heat Rashes
- Heat edema
- Heat syncope
- Heat Exhaustion
- Heat Stroke
HEAT CRAMP

- Hot environment causes profuse sweating
- Na+ (sodium) lost in sweat
- Lack of Na+ causes muscle cramping
- C/P:
  - Cramps of fingers, arms, legs, abdominal muscles
  - Nausea
  - Normotensive, mild hypotension
  - Tachycardia
  - Cool, pale skin
  - Awake, normal body temperature
HEAT CRAMP

Management:
- Move to cool place, rest, lie down
- Give balanced salt/water solution (Electrolyte Solution)
- Salt alone leads to increased nausea, increased water loss
- Water alone leads to worsened cramping (dilutional hyponatremia)
Prickly Heat (Heat Rash)
Heat causes the blood vessels to expand (dilate), so body fluid moves into the hands or legs by gravity.
Heat causes an increase in blood flow to the skin and pooling of blood in the legs, which can lead to a sudden drop in blood pressure followed by syncope.
HEAT EXHAUSION

Pathophysiology:

- Increased vascular space due to vasodilatation.
- Decreased blood volume due to sweating.
- Decreased CNS perfusion.
RISK GROUP:

- People working in hot, humid environments
- Elderly, due to decreased thirst mechanism
- Hypertensive pt due to medication effects
Heat Exhaustion

Symptoms: similar to a viral infection:

- Fatigue and weakness
- Nausea and vomiting
- Headache and myalgia
- Dizziness
- Irritability
Heat Exhaustion

Physical Findings:

- Orthostatic pulse and blood pressure changes
- Sweating
- Tachycardia
- Temperature is usually less than 41°C
- Normal mental status!
Heat Exhaustion

Treatment:

- Move to cool place, stop activity, lie down Supine, and legs elevated
- Cooling
- Balanced salt/water (electrolyte) solution, or IV fluid with NaCl, if pt too nauseated to drink.
<table>
<thead>
<tr>
<th>Heat Exhaustion:</th>
<th>Heat Stroke</th>
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<tbody>
<tr>
<td>• Heavy sweating</td>
<td>• No sweating</td>
</tr>
<tr>
<td>• Heavy thirst</td>
<td>• Red or flushed, hot dry skin</td>
</tr>
<tr>
<td>• Panting/rapid breathing</td>
<td>• Any symptom of heat exhaustion but more severe</td>
</tr>
<tr>
<td>• Rapid pulse</td>
<td>• Difficult breathing</td>
</tr>
<tr>
<td>• Headache</td>
<td>• Pinpoint pupils</td>
</tr>
<tr>
<td>• Blurred vision</td>
<td>• Bizarre behavior</td>
</tr>
<tr>
<td>• Exhaustion, weakness</td>
<td>• Convulsions</td>
</tr>
<tr>
<td>• Clumsiness</td>
<td>• Confusion</td>
</tr>
<tr>
<td>• Confusion</td>
<td>• Collapse</td>
</tr>
<tr>
<td>• Dizziness or fainting</td>
<td></td>
</tr>
<tr>
<td>• Cramps</td>
<td></td>
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</table>
HEAT STROKE
A core temperature $\geq 40^\circ C$ accompanied by CNS dysfunction in patients with environmental heat exposure.

This condition represents a failure of the body's ability to maintain thermoregulatory homeostasis.
Types of heat stroke

A- Classical type:

- Occurs mainly in the extremities of age.
- Gradual in onset [commonly more than 48 hours].
- Dehydration is more due to prolonged sweating.
- At presentation, skin is commonly dry.
Types of heat stroke

**B- Exertional type:**

- Occurs commonly in middle aged healthy persons.
- Occurs in non-acclimatized persons during exercise or hard work in hot humid atmosphere.
- Rapid onset.
- Less dehydration.
<table>
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<tr>
<th>Characteristics</th>
<th>Classical HS</th>
<th>Exertional HS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group</td>
<td>Older</td>
<td>Young</td>
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<tr>
<td>Occurrence</td>
<td>Epidemic</td>
<td>Sporadic</td>
</tr>
<tr>
<td>Predisposing illness</td>
<td>Frequent</td>
<td>Rare</td>
</tr>
<tr>
<td>Weather</td>
<td>Heat wave</td>
<td>Variable</td>
</tr>
<tr>
<td>Acid-base status</td>
<td>Respiratory alkalosis</td>
<td>Respiratory alkalosis + lactic</td>
</tr>
<tr>
<td>acidosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhabdomyolysis, renal failure, DIC</td>
<td>Rare</td>
<td>Common</td>
</tr>
<tr>
<td>Hyperuricemia</td>
<td>Mild</td>
<td>Marked</td>
</tr>
</tbody>
</table>
Predisposing factors:

- Environmental factors: Exposure to hot humid weather with decreased air current.
- Non Acclimatization.
- Epidemic heat stroke Occurs when a city experienced a cold winter followed by a hot humid weather in the late spring or early summer.
- Wearing heavy clothes in a hot atmosphere.
Predisposing factors:

- Military personal, athletes & young people doing exercise or hard work in hot humid weather.
- Age: Children & elderly is the most vulnerable.
- Obesity
- Dehydration
Predisposing factors:

- Chronic illness:
  - C.V. diseases, Diabetes M - Hemi or quadriplegia with autonomic dysfunction, Infection
- Drugs: Anti-cholinergic drugs, major tranquilizers, phenothiazine and neuroleptic drugs.
Difference between fever and hyperthermia

- **Fever** is an upward adjustment of the set-point, unlike hyperthermia.
- Therefore, fever does not represent a failure of temperature control, but rather an upward shift of the regulated temperature.
Difference between fever and hyperthermia

- Fever usually occurs as a result of the body's exposure to:
  1. Infecting micro-organisms
  2. Immune complexes
  3. Other sources of inflammation
In 1980, heat wave in U.S. lead to 1700 deaths.

In 1998, heat wave in India leaded to 2600.

In 2003, heat wave caused 1000 deaths in India.

About 10000 victims were lost in France only during the heat wave of Europe in 2003.

1000 deaths in India may 2015.
Effects of hyperthermia on the body

At 42 degree:

- **Denaturation** of proteins, enzymes & hormones.

- **Liquefaction** of lipids including the brain tissue.

- **Oxidative** phosphorelation decrease with loss of energy sources to different tissues including the heat regulating centre.
Effects on the brain

The 1st cell to be affected is the brain cell leading to:

1. Mental changes, stupor & coma.
2. Convulsions or decerebrate rigidity.
3. Quadriplegia, hemiplegia or monoplegia
4. Different brain infarctions.
5. Paralysis of centers like heat regulation center or respiratory center leading to death.
Effects on the Liver

Degeneration then necrosis to the liver cells which may lead to liver cell failure.
Effects on the Kidney & skeletal muscle

- Destruction of the renal cells leading to renal failure.
- Destruction of the skeletal muscle cells [rhabdomyolysis] specially in exertional type, leading to myoglobinuria with possibility of renal tubular obst. and renal failure.
- Precipitation of Ca. & Ph. on the destructed muscle cells leads to hypocalcaemia & hypophosphatemia.
- Also Na. inter the cells & K. go outside the cells leading to hyperkalemia & hyponatremia
Effects on the cardiovascular system

- Injury to the endothelial lining of the vessels causing D.I.C.
- Affects the conductive system of the heart that may lead to different types of arrhythmias and heart failure
Clinical picture

Symptoms Occurs prior to coma in the form of:

- Headache
- Nausea & vomiting.
- Light headedness.
- Paresthesias and Change of behavior.
- then syncope & coma.
**SIGNS**

**Body temperature:**
- Must be taken rectally, usually over 41 degree, may be cold extremities due to peripheral circulatory failure.

**Heart rate:**
- with dehydration or heart failure: tachycardia + weak pulse
- Irregular pulse in arrhythmia & Bradycardia in heart block.
**SIGNS**

**B I . P . :**
- May be: low due to low output failure [dehydration] or high output failure [high temp.]

**Respiratory rate:**
- Deep rapid respiration. Usually due to high temp.
- Irregular resp. [chyne stoke] in the terminal stage
- Bubbling crepitation & frothy sputum in pulmonary edema.
SIGNS

**Skin:**
- Usually grey & dry. may be flushed and sweaty.
- Sweat rash is usually present.

**CNS:**
- Coma with dilated fixed pupils, convulsions, muscle rigidity, tremors, hemiplegia may be present.
Diagnostic Tests
Blood Gases:

Commonly reveals:

- **metabolic acidosis** due to lactate accumulation specially in exertional type.

- **Respiratory alkalosis** may be present due to hypercapnia.
Blood picture:

Leucocytosis is common, may reach high levels [35,000 – 50,000/cmm.]

N.B:

The A.S.T. Level is prognostic, the level of 1000 i.U./Liter or more in the first 24 hours reflects a poor prognosis with serious brain, liver & renal damage and the reverse.
C.K. [creatinine kinase]:

- Markedly elevated specially in exert. type.

Myoglobinurea & Hyperuricemia:

- Usually present due to destruction of muscle fiber
Electrolytes:

- ± Na
- ↑ K in first 24 hours.
- ↓ Ca due to precipitation in the damaged fibers.
- ↓ Ph due to the same reason
E.C.G.:

- S-T segment & T wave abnormality with varieties arrhythmias and BBB. may occur and most of them are reversible after cooling.
Mortality/Morbidity

- Duration of the temperature elevation.
- Delayed therapy - mortality rate may be as high as 80%.
- Early diagnosis and immediate cooling -10%.
- Highest among the elderly population, pts with preexisting disease, those confined to a bed, and those who are socially isolated.
Differential diagnosis

- Acute CNS infection
- Cerebral malaria
- Severe sepsis
- Neuroleptic malignant syndrome
- Malignant hyperthermia
- Thyroid storm
Management

- Heat stroke is one of the medical emergency that needs rapid interference.

- The seconds are precious for the patient, so our aim is to decrease the body temp. below the harmful level as quickly as possible to avoid irreversible cellular damage.

- Pre-hospital cooling: decrease morbidity and mortality rate.
Cooling

There are 2 different methods for cooling:

1. the aggressive cooling measures.
2. the slow evaporative technique.
A-Aggressive cooling measures

It includes:

1. Direct application of ice on the whole body.
2. Immersing the body in cold or iced water.
3. Application of ice in areas of great vessels e.g. axilla, groin & front of the neck.
4. Gastric lavage with iced fluids.
5. Enema with iced fluids.
6. Peritoneal lavage with iced fluids.
7. I.V. infusion of cold fluids.
8. Inhalation of cold air.
Disadvantages of these methods:

- The cooling rate is less [0.1 degree/min.] except in peritoneal lavage [0.55 degree/min.]
- Difficult for application in comatose patient.
- May cause shivering which increases body temp.
- Direct ice to the skin leads to vasoconstriction.
- Ice enema may cause shock and sudden death.
- Peritoneal lavage may lead to peritonitis.
B-Slow evaporative technique

The idea depends on the smooth cooling effect of the evaporated water.
B-Slow evaporative technique

**TECHNIQUE:**

- This is done by spraying the body with water, then expose the body to strong current of dry air.
- This process continues until the temp. reaches 39 degree, then cooling must be stopped.
B-Slow evaporative technique

Advantages of the technique:

- Faster rate of cooling [0.33 deg./min.]
- Easily applied for comatose patient.
- Not cause shivering or peripheral v. c. This method must be done in specialized center.
The heat stroke & heat exhaustion center
The heat stroke & heat exhaustion center

The center is composed of:

- 2 suitable rooms: * cooling room. * observation room.
cooling room:

- Enough number of air conditions insure a temp. room 25-30 (average 27) and also dry air.
- Slated beds without mattresses.
- Opposite to each bed one fan must be fixed to wall to supply a horizontal current of air.
- A number of suction fans in the upper part of the wall for renewal of air & removal of humid air.
- A source of tape water & ice must be in the cooling room. - All equipments and emergency drugs needed for comatose patient must be supplied.
King Saud University cooling bed.

(A) stainless steel pan; (B) drain pipe; (C) rubber strips fixed on steel stretcher; (D and E) electric fans adjustable in three dimensions; (F) panel for temperature probes, and single electricity outlet for whole unit.
The second room is a neighboring conditioned room containing normal beds for observation for 24 h. after cooling.
Assessment and management of A,B,C
Airway, breathing, circulation

- Oxygen
- TT of seizures:
  Midazolam: 0.1 - 0.2 mg/kg IV, max 4 mg
- TT of shivering:
  chlorpromazine: 10 – 25 mg IM or Midazolam
TT of hypotension:

usually result from:

- Peripheral vasodilatation
- Volume depletion (dehydration)
- Cardiac dysfunction
  - Use crystalloid solution as normal saline to maintain urine output 50 ml / h.
  - Excessive fluid administration may result in pulmonary edema
MEDICAL TREATMENT

- **Antipyretic medications** (acetaminophen and ibuprofen): are *ineffective* and should not be used as it may exacerbate liver injury and coagulation disorders.

**Treatment of end organ dysfunction:**

- Respiratory dysfunction
- Cardiac dysfunction and arrhythmia
- Acute kidney injury and rhabdomyolosis
- Hepatic injury
- DIC
Thanks