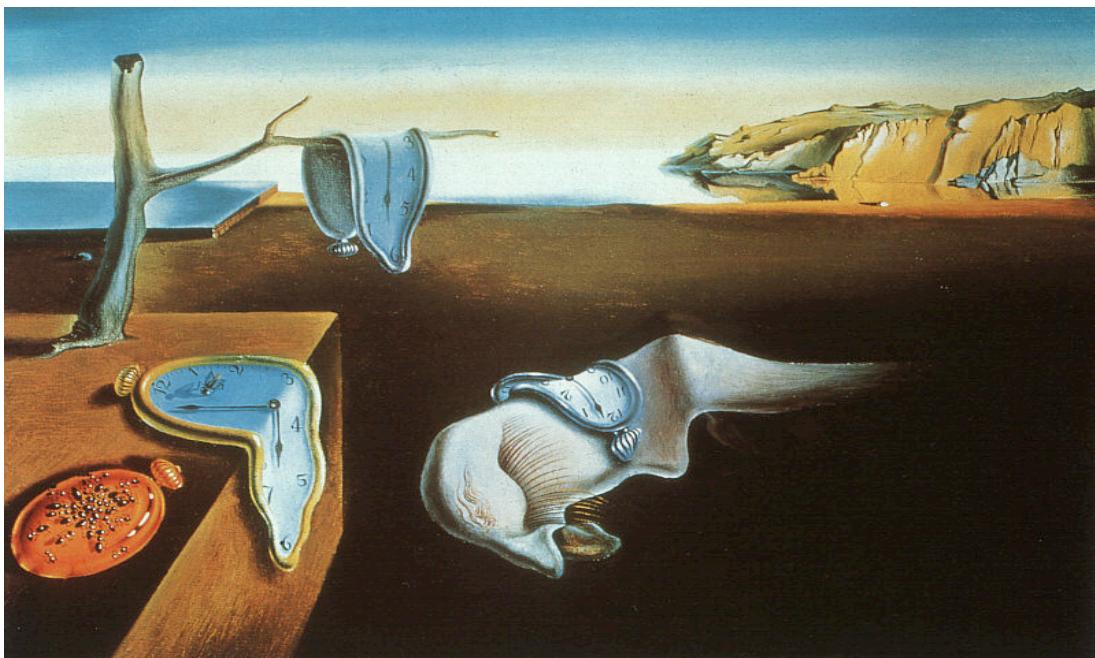
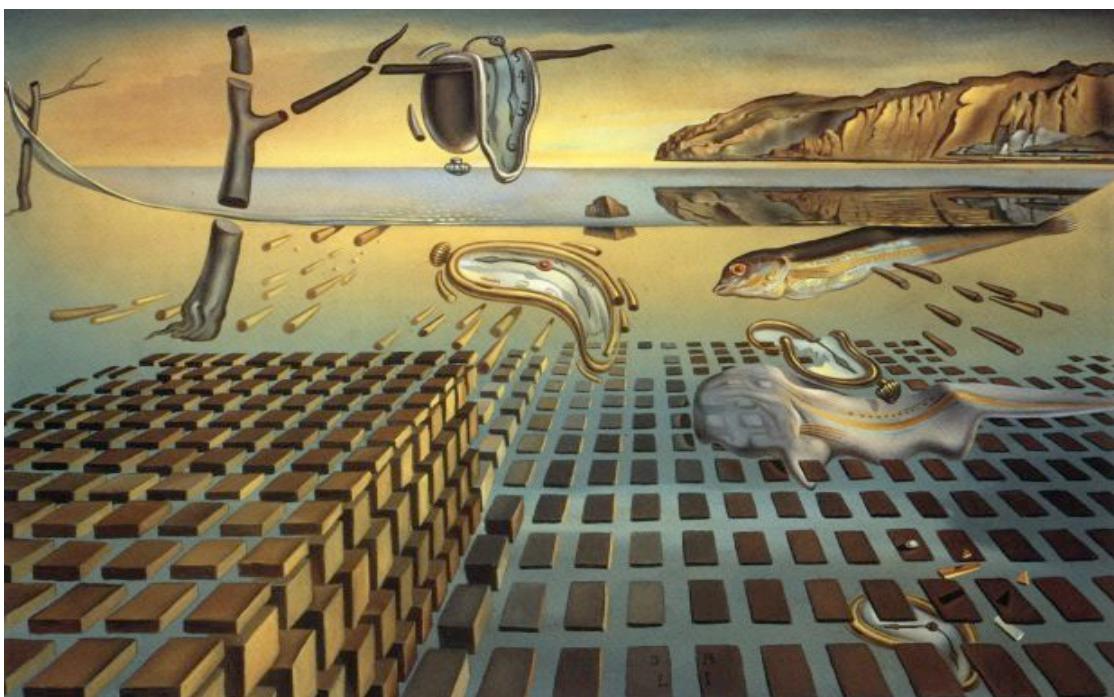




HEATSTROKE



"The Persistence of Memory", Salvador Dalí, 1931, Oil on canvas. The Museum of Modern Art, New York



"The Disintegration of Persistence of Memory", Salvador Dalí, 1952-54, Oil on canvas. The Salvador Dalí Museum, St. Petersburg, Florida

Salvador Dali's the "Persistence of Memory" is probably his most recognizable and haunting work. Dali's works mean many different things to many different people. To an Emergency Medicine physician "The persistence of Memory" and the "Disintegration of the persistence of Memory" may serve as a reminder of the potentially devastating effects of heatstroke. The melting clocks remind us of the potential effects of hyperthermia as well as the "time critical" element in the treatment of this condition. Initially memory or neurological function persists intact, as in Dali's first painting. However, given enough time left untreated there will be devastating neurological consequences, as in the second painting, with the rapid disintegration of memory as well as all other neurological functions.

HEATSTROKE

Introduction

Heatstroke is a clinical syndrome characterized by exposure to an excessive heat load, together with a failure of the normal thermoregulatory systems of the body to cope with this.

It is a clinical diagnosis, based on the three hallmark features of neurological impairment, severe hyperpyrexia, and a history of exposure to an environmental heat load.

This condition has high mortality and morbidity and is a true time critical medical emergency.

Once heatstroke is suspected, the temperature must be lowered as quickly as possible.

Pathophysiology

Causes:

To make a diagnosis of "heatstroke", there must be a history of significant environmental exposure.

There are 2 important factors here:

- High ambient temperatures
- High ambient humidity.

The **wet bulb globe** thermometer reading takes into account not only the ambient temperature, but also the ambient humidity. Over 90 % of heat syndrome cases are associated with wet bulb globe thermometer readings of 30°C or more.

Further predisposing factors include:

1. Age extremes:
 - Infants and elderly, during "heat waves".
2. Occupations:
 - Athletes, labourers and the military.

3. Concurrent drugs:

- Especially anti-cholinergic agents, (which inhibit sweating)

4. Psychological factors:

- Belief of “invulnerability” of the young for example!

5. Rarely pathological conditions of the sweat glands, including:

- Cystic fibrosis.
- Quadriplegia
- Congenital anhidrosis.

Complications:

The prime complications of heatstroke are those of CNS dysfunction, rhabdomyolysis and dehydration.

1. CNS

- Confusion
- Hallucinations
- Altered conscious state
- Seizures
- Coma

2. Rhabdomyolysis:

- The immediate complication here will be hyperkalemia.
- The delayed complication will be renal failure due to myoglobinuria.

3. Fluid and electrolyte disturbance:

- Dehydration:
- Lactic acidosis, (dehydration, and disturbed oxidative phosphorylation at temperatures of 42°C)

4. CVS:

- High output cardiac failure, especially in the elderly, (early)

- Myocardial depression in more severe cases, (late)
5. Hepatic damage:
- Acute fulminant hepatic failure may occur.
6. Renal:
- Acute renal failure, due to dehydration and myoglobinuria.
7. Long term sequelae:
- Without urgent and adequate treatment
- Mortality is up to 40 %
 - In survivors:
 - ♥ Neurological problems, (especially cerebellar)
 - ♥ Impaired thermoregulation ability.

Clinical Features

Heatstroke is ultimately a clinical diagnosis as well as one of exclusion.

It has three essential components:

1. **CNS dysfunction**, (the cardinal clinical manifestation).
2. **Severe hyperpyrexia**, (generally defined as **41⁰ C or higher**)
3. History of exposure to an **environmental heat load**.

Further features of note include:

4. Failure of thermoregulatory mechanisms:
 - Evidence of a lack of normal heat coping mechanisms as shown by **anhidrosis** is also often quoted, however this is not an absolute diagnostic criterion and indeed profuse sweating may be seen in some severely affected patients.

With severe hyperthermia, sweating mechanisms can fail and the skin may be paradoxically dry.
5. Nausea and vomiting are also commonly seen
6. Rapid response to treatment:

- Heatstroke has a typical history and there is usually a quick response to adequate treatment, provided the patient has not suffered irreversible brain injury prior to the initiation of treatment.

Indeed if the patient does not adequately respond to rapid cooling measures, either there is an alternative diagnosis or irreversible damage has already occurred.

Differential Diagnoses:

The most important differential diagnoses that need to be considered include:

1. Infections, especially:
 - Of the CNS, cerebral abscess, meningitis and encephalitis.
 - Severe systemic infection including bacterial and malaria.
2. Prolonged status epilepticus
3. Hyperthermic drug reactions:
 - Malignant hyperthermia
 - Neuroleptic malignant syndrome
 - Serotonin syndrome
 - CNS stimulant drugs of abuse, amphetamines and similar, cocaine.
4. Severe delirium tremens
5. Thyrotoxic storm, (rare)

Investigations

The following investigations will need to be considered:

Blood tests:

1. FBE
2. CRP
3. U&Es and **glucose**
4. CK
5. Myoglobin level.
6. Troponin I

7. LFTs
8. ABGs
9. Blood cultures.

CXR:

- To look for a pneumonic source of fever.

ECG:

- Non-specific ST-T wave changes may occur.

CT Brain:

- This should be strongly considered in all cases, as “heatstroke” will largely be a diagnosis of exclusion and other CNS conditions causing fever and altered conscious state need to be ruled out.

Equally patients with heatstroke may suffer secondary pathology such a cerebral hemorrhage.

When the clinical picture appears clear, then urgent cooling will take preference over CT scan of the brain. If there is not the expected response to aggressive cooling measures, then CT of course should be done for those with an altered conscious state.

CSU:

- M&C, (to help rule out a source of infection)
- Myoglobin levels.
- Consider urine drug screen

Management

Once heatstroke is suspected, the temperature must be lowered as quickly as possible.

It does not take long to boil an egg nor to cook neurones!

Morbidity and mortality is directly related to both the temperature level and the duration of time the patient suffers from it.

The principles of management of heatstroke include:

1. Immediate resuscitation measures.
2. Urgent cooling measures
3. Exclusion of other causes of hyperthermia.

4. Look for and treat any secondary complications.

Immediate Resuscitation Measures:

1. Immediate attention to any ABC issues.
2. IV access and take bloods, check **glucose**.
3. Establish monitoring:
 - ECG
 - Pulse oximetry.
 - Ongoing core temperature monitoring in the ED with the **Curity 12 French Foley urinary catheter with temperature probe**.
4. Commence IV fluid resuscitation as necessary.

Urgent cooling measures

Temperatures of 41°C or above need urgent and aggressive cooling.

1. Remove all clothing.
2. Commence cooling with electric fans, to enhance evaporative heat loss.
 - This is fast, effective and non-invasive and is the method of choice in the rapid treatment of heatstroke.
3. Place ice packs:

These should be to areas of large superficial veins, (to avoid a generalized vasoconstriction, which may inhibit heat loss)

- Neck
 - Axillae
 - Groin
4. Tepid water sponging:
 - Tepid water (15°C) sponging. Note that ice water and very cold air are best avoided as this may induce shivering and vasoconstriction which act to reduce core heat loss.
 5. **Cooled IV fluids:**²
 - **30 mls/kg** of Hartman's solution that has been cooled to 4°C given as a **rapid bolus infusion**, (ie fluid can be infused rapidly over 20 minutes)

6. Drug treatment:

- IV diazepam
- IV chlorpromazine, (however beware excessive sedation and hypotension)

These will reduce shivering and excessive muscular activity in agitated patients.

Note that antipyretic drugs are **not** effective in heatstroke.

7. Other cooling methods:

- More aggressive measures are described such as cold water gastric lavage, bladder lavage, even peritoneal lavage, however these are rarely, if ever used in practice, and their effectiveness is unproven. Indeed if the usual methods above are failing intubation and ventilation may be required and/ or an alternative diagnosis needs to be considered, and/ or secondary complications need to be considered.

8. Intubation and paralysis:

- Intubation, paralysis and ventilation may ultimately be required for severely agitated and combative patients, especially with seizures and rhabdomyolysis.

Once the core temperature has reached 38 ° C, more active measures should be ceased to prevent hypothermia from occurring.

Exclusion of other causes of hyperthermia:

It is important to keep in mind the possibility of sepsis, drug reaction and status epilepticus as differential diagnoses of heatstroke as treatment is obviously different.

Septic workup should be done and if infection cannot readily be ruled out it is safest to give broad-spectrum antibiotics in the first instance.

It is important to aggressively treat any seizure activity

Look for and treat any secondary complications:

The most important secondary complications to look for will be dehydration and rhabdomyolysis. In particular check for and treat any hyperkalemia.

Prognostic features

Note that the elevated temperatures and destructive processes of true heatstroke are entirely different from the milder and much better tolerated elevated temperatures of other disease processes, which usually have no significant mortality of their own.

Prognostic features include:

1. The temperature level, (worse prognosis > 42 ° C)

2. The duration of the hyperthermia.
3. Extremes of age
4. Coma, including the duration of coma.
5. Underlying medical conditions.
6. Biochemical disturbances, including, acidosis, DIC and abnormal LFTs.

References:

1. Walker JS, Vance MV: Heat Emergencies in Emergency Medicine, Tintinalli et al 4th ed 1996, p.850-856.
2. Brown AFT, Cadogen M. "Heat Related Illness" in Emergency Medicine 5th ed 2006

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