# Management of Heat Stroke(Hyperpyrexia)

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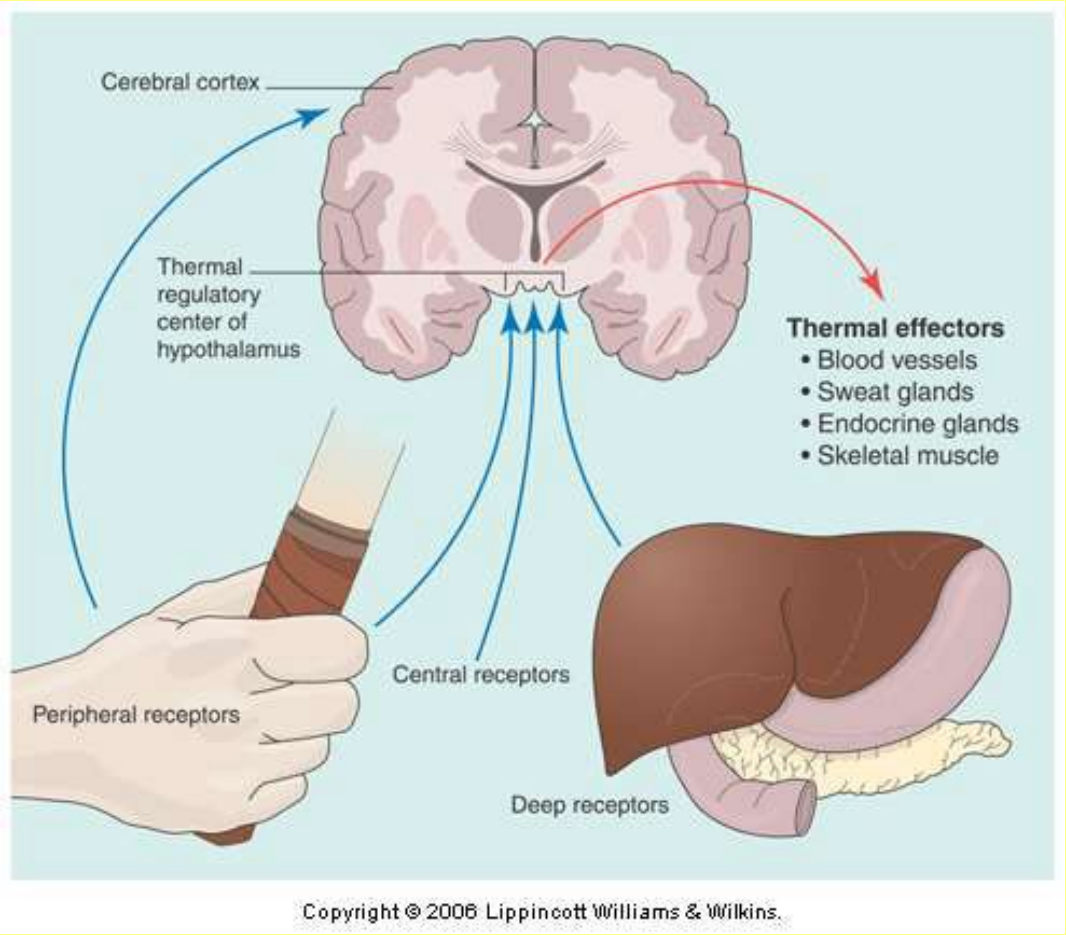
# DEFINITION

A core temperature ≥40°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.

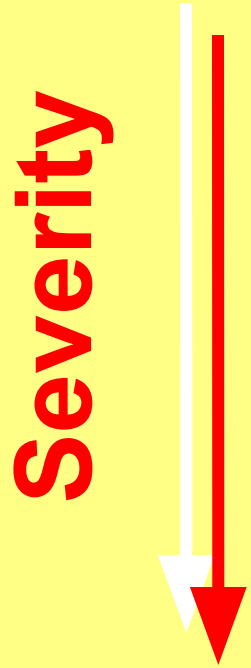
# Pathophysiology

- Excessive heat denatures proteins, destabilizes phospholipids and lipoproteins, and liquefies membrane lipids, leading to cardiovascular collapse, multiorgan failure, and, ultimately, death.
- In a simplified model, thermosensors located in the skin, muscles, and spinal cord send information regarding the core body temperature to the anterior hypothalamus, where the information is processed and appropriate physiologic and behavioral responses are generated. Physiologic responses to heat include an increase in cardiac output and blood flow to the skin (as much as 8L/min), which is the major heat dissipating organ; dilatation of the peripheral venous system; and stimulation of the eccrine sweat glands to produce more sweat.
- Hypothalamic dysfunction may alter temperature regulation and may result in an unchecked risen temperature and heat illness.

# Hypothalamus Regulation of Temperature



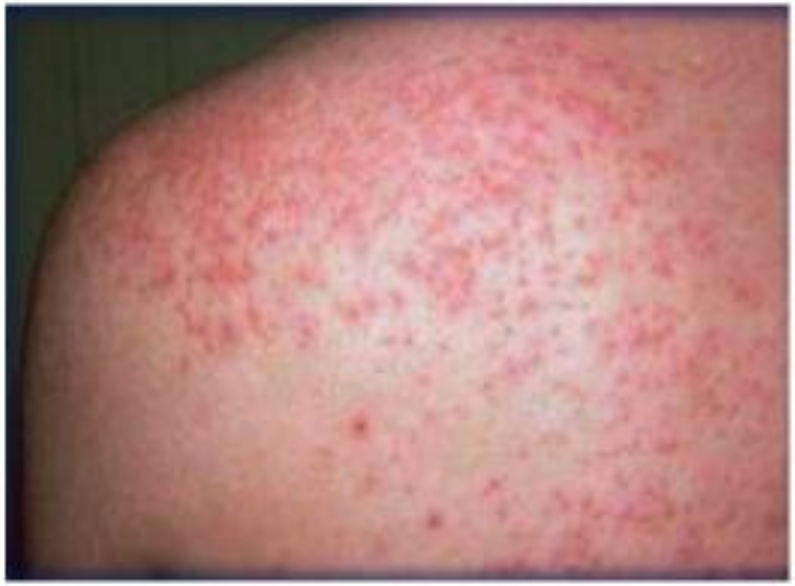
# Heat Illnesses (Hyperthermia)

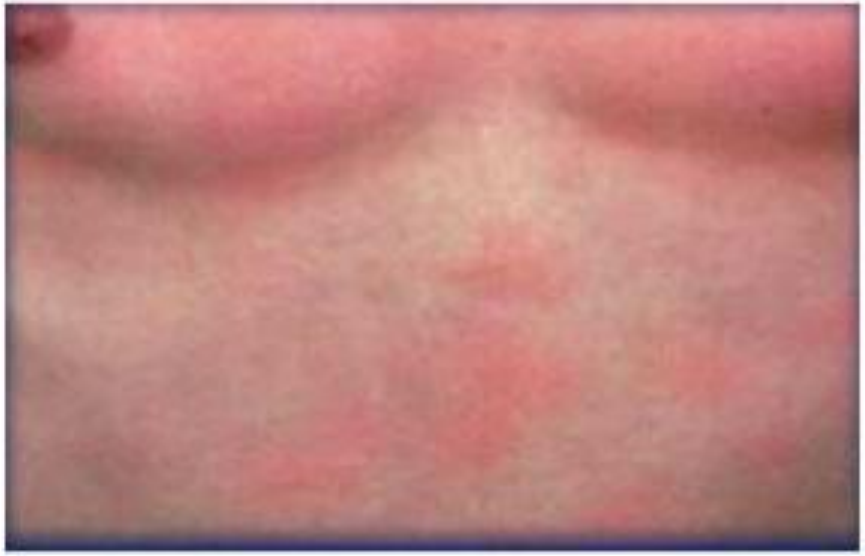



- Heat rash
- Sunburn
- Heat cramps
- Heat exhaustion
- Heat stroke

# Heat Rash

- Acute inflammation of sweat ducts
- Ducts become dilated and rupture
- Pruritic MP rash in clothes area
- Treat with antihistamine





*Melissa Platt and Timothy G. Price Rosen's Emergency Medicine: Concepts and Clinical Practice, Chapter 133*

# Heat Cramps

- Painful , involuntary contraction of muscle esp at calves and thighs
- Electrolyte abnormalities (dysnatremia ,dyskalemia)
- Treatment by rest in cool environment , fluid and salt replacement or IVF

*Melissa Platt and Timothy G. Price Rosen's Emergency Medicine: Concepts and Clinical Practice, Chapter 133*

# Heat Exhaustion

- Clinical : Severe fatigue , dizziness, vomiting , myalgia
- Tachycardia and tachypnea
- Profound sweating
- Core temp – normal up to 40 °C
- Mental status is NORMAL
- Treatment by IV salt and water repletion
- Admission usually required

*Melissa Platt and Timothy G. Price Rosen's Emergency Medicine: Concepts and Clinical Practice, Chapter 133*

## Clinical features of heat stroke and heat exhaustion*

| | Heat stroke | Heat exhaustion |
|---|---|---|
| **Core body temperature** | >40°C (104°F)[Δ] | ≤40°C (104°F) |
| **Mental status** | Abnormal mental status (eg, obtunded, coma, delirium, hallucinations, seizures, ataxia, slurred speech) | Normal mental status, dizziness, or mild confusion that rapidly normalizes within 30 minutes of treatment. May see syncope with rapid recovery of alertness. |
| **Airway and breathing** | May be compromised due to altered mental status, tachypneic | Clear airway, may be tachypneic |
| **Circulation** | Tachycardia with hypotension, moderate to severe dehydration | Tachycardia with normal blood pressure, mild to moderate dehydration |
| **Skin findings** | Dry skin (classic heat stroke) or sweating (exertional heat stroke) | Sweating |
| **Other clinical features** | ▪ Vomiting<br>▪ Diarrhea<br>▪ Clinical and laboratory findings of DIC, rhabdomyolysis, acute renal failure, cardiogenic shock, and liver failure | ▪ Nausea, vomiting<br>▪ Headache<br>▪ Fatigue, weakness<br>▪ In some patients, hyponatremia or hypernatremia |

# Forms

**1) Classic , or nonexertional , heatstroke (NEHS)**

- Classic heat stroke , which occurs during environmental heat waves , is more common in the very young and the elderly and should be suspected in children , elderly persons , and chronically ill individuals who present with an altered sensorium.
- Classic heatstroke occurs because of failure of the body's heat dissipating mechanisms

# 2. Exertional heatstroke

- EHS affects young, healthy individuals who engage in strenuous physical activity, and EHS should be suspected in all such individuals who exhibit bizarre, irrational behavior or experience syncope.
- Both types of heat stroke are associated with high morbidity and mortality , especially when cooling therapy is delayed.
- EHS results from increased heat production, which overwhelms the body's ability to dissipate heat.

# Who's at risk?

Elderly

Military

Children

Outdoor workers

# DIAGNOSTIC EVALUATION

- **Clinical assessment:**

  The diagnosis of heat stroke is based upon a careful history and physical examination.

# Core temperature measurement

- Should be determined in all patients and continuously monitored.
- **Rectal** temperature is the most commonly obtained core temperature measurement, although esophageal, central venous, pulmonary artery, or bladder probe temperature are potential alternatives.
- Oral, axillary, or tympanic membrane temperatures are unreliable in treating heat illness.

# Laboratory findings

- Rapid blood glucose to identify hypoglycemia
- Blood gas (venous or arterial) to evaluate for the presence and severity of metabolic acidosis
- CBC,(PT), (PTT), INR and Serum electrolytes .
- Liver enzymes to assess for liver injury
- Urea and creatinine to identify prerenal azotemia or renal failure resulting from myoglobinuria
- Serum (CK), ionized or total calcium, and phosphate to detect rhabdomyolysis , hypocalcemia and hyperphosphatemia
- Urine rapid dipstick and urinalysis to diagnose myoglobinuria
- Toxicologic screening for drugs of abuse or prescribed medications

- **Chest radiograph:**
  Helps identify pulmonary edema and is useful in patients for whom pulmonary aspiration is a concern.
- **Electrocardiogram:**
  Should be obtained in patients with electrolyte abnormalities (eg, hyperkalemia, hypokalemia, hypocalcemia) and/or rhabdomyolysis.
- **Computed tomography:**
  CT-Brain should be obtained if one has persistently altered mental status despite cooling or shows signs of increased intracranial pressure suggestive of cerebral edema or intracranial hemorrhage.

# DIFFERENTIAL DIAGNOSIS

- Sepsis
- Central nervous system conditions
- Status epilepticus
- Toxic overdose
- Serotonin syndrome
- Hemorrhagic shock and encephalopathy syndrome
- Neuroleptic malignant syndrome
- Thyroid storm
- Malignant hyperthermia

# Physical Examination

- **Vital signs**
- Temperature: Typically, temperature exceeds 41°C.
- Pulse: Tachycardia, exceeding 130 beats per minute is common.
- Blood pressure: Patients commonly are normotensive, with a wide pulse pressure; however, hypotension is common and may result from a number of factors, including vasodilation of the cutaneous vessels, pooling of the blood in the venous system, and dehydration.

# Central nervous system

- Symptoms may range from irritability to coma.
- Patients may present with delirium, confusion, delusions, convulsions, hallucinations, ataxia, tremors, dysarthria, and other cerebellar findings, as well as cranial nerve abnormalities and tonic and dystonic contractions of the muscles. Patients also may exhibit decerebrate posturing, decorticate posturing, or they may be limp.
- Coma also may be caused by electrolyte abnormalities, hypoglycemia, hepatic encephalopathy, uremic encephalopathy, and acute structural abnormalities, such as intracerebral hemorrhage due to trauma or coagulation disorders.
- Cerebral edema and herniation also may occur.

# Cardiovascular

- Heat stress places a tremendous burden on the heart. Patients with preexisting myocardial dysfunction do not tolerate heat stress for prolonged periods.
- Patients commonly exhibit a hyperdynamic state, with tachycardia, low systemic vascular resistance, and a high cardiac index.
- Hypodynamic state, with a high systemic vascular resistance and a low cardiac index, may occur in patients with pre existing cardiovascular disease and low intravascular volume.
- A hypodynamic state also may signal cardiovascular collapse.

# Pulmonary

- Patients with heat stroke commonly exhibit tachypnea and hyperventilation caused by direct CNS stimulation, acidosis, or hypoxia.
- Hypoxia and cyanosis may be due to a number of processes, including atelectasis, pulmonary infarction, aspiration pneumonia, and pulmonary edema.
- ARDS develop because of multiple insults, including heat induced pulmonary damage, aspiration pneumonia, and as a complication of liver failure.

# Digestive

- Gastrointestinal hemorrhage occurs frequently in heat stroke patients.
- Patients commonly exhibit evidence of hepatic injury, including jaundice and elevated liver enzymes. Hypoglycemia, abnormal coagulation, cerebral edema, and death can occur.
- Rarely, fulminant hepatic failure occurs, accompanied by encephalopathy, hypoglycemia, and disseminated intravascular coagulation(DIC) and bleeding.
- Prolonged coagulation times also may signal the development of DIC, which, when present, carries a poor patient prognosis. DIC also may predispose patients to development of acute respiratory distress syndrome(ARDS), which also increases mortality.

## •Musculoskeletal

- Muscle tenderness and cramping are common; rhabdomyolysis is a common complication of EHS .The patient's muscles may be rigid or limp.
- Renal
- Acute kidney injury is a common complication of heat stroke and may be due to hypovolemia, low cardiac output, and myoglobinuria(from rhabdomyolysis).Patients may exhibit oliguria and a change in the color of urine.

# Complications

- The central nervous system(CNS) is especially sensitive to the damaging effects of hyperthermia. Widespread cell death occurs but is more evident in the region of the cerebellum(Purkinje cells).
- Heatstroke–related long-term CNS sequelae include cerebellar deficits, dementia, hemiplegia, quadriparesis, and personality changes.

- Rhabdomyolysis was observed in almost all patients with EHS and in as many as 86% of patients with NEHS.
- Compartment syndrome is observed most commonly in patients with severe rhabdomyolysis and in patients who are immobilized.
- Acute kidney injury may occur in as many as 25-30% of patients who have heatstroke (especially EHS).

- Acute liver failure due to centrilobularhepatic necrosis and cholestasis generally occurs in the first 48 hours, but it can peak as long as 2 weeks after the onset of heatstroke.
- DIC is a rare complication and caries a poor prognosis when it occurs.
- ARDS may be due to direct thermal injury to the lung, or it may complicate liver failure, infection, or aspiration

- **Arterial blood gas** analysis may reveal respiratory alkalosis due to direct central nervous system(CNS) stimulation and metabolic acidosis due to lactic acidosis. Hypoxia may be due to pulmonary atelectasis, aspiration pneumonitis, or pulmonary edema.
- Lactic acidosis commonly occurs following exertional heatstroke (EHS) but may signal a poor prognosis in patients with classic heat stroke.
- Blood glucose, Hypoglycemia may occur in patients with EHS and in patients with fulminant hepatic failure.

# Electrolytes

- Hypernatremia due to reduced fluid intake and dehydration commonly is observed early in the course of disease but may be due to diabetes insipidus.
- Hyponatremia is observed in patients using hypotonic solutions, such as free water, and in patients using diuretics. It also may be due to excessive sweat sodium losses.
- Hypokalemia is common in the early phases of heatstroke, and deficits of 500 mEq are not unusual. However, with increasing muscle damage.
- Hyperkalemia may be observed commonly.

# Hepatic function tests

- Aminotransferase (aspartate aminotransferase [AST] and alanine amino transferase [ALT] levels commonly rise to the tens of thousands during the early phases of heatstroke and peak at 48 hours, but they may take as long as 2 weeks to peak.
- Jaundice may be striking and may be noted 36-72 hours after the onset of liver failure.

# Muscle function tests

- Creatinine kinase (CK), lactate dehydrogenase (LDH), aldolase, and myoglobin commonly are released from muscles when muscle necrosis occurs.
- CK levels exceeding 100,000 IU/mL are common in EHS.
- Elevations in myoglobin may not be noted despite muscle necrosis because myoglobin is metabolized rapidly by the liver and excreted rapidly by the kidneys.

- **Complete blood cell count**
- Elevated white blood cell counts commonly are observed in patients with heatstroke, and levels as high as 40,000/μL have been reported. Platelet levels may below.
- **Renal function tests**
- Elevations in serum uric acid levels, blood urea nitrogen, and serum creatinine are common in patients whose course is complicated by renal failure.
- **Urinalysis**
- Presence of red blood cells, and proteinuria are common.

# 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.

# PREHOSPITAL CARE

- Cooling might have occurred prior to the arrival of the hospital.
- Removal from the source of heat stress and rapid initiation of cooling, as the risk of morbidity and mortality for patients with heat-related illness is associated with the duration of hyperthermia.

- Evaporative cooling may be accomplished in the field by spraying patients with water or saline and fanning these patients, either manually or with ambulance fans or air conditioners.
- Application of ice packs to the neck, axillae, and groin.
- The institution of pre-hospital cooling should not delay timely transportation to definitive care.


Use a fan to lower temperature
Elevate feet
Apply cold compresses
Have victim lie down
Have victim drink fluids
A.D.A.M.

# COOLING

- There are 2 different methods for cooling:
  1) the aggressive cooling measures .
  2) the slow evaporative technique.

# A-Aggressive cooling measures

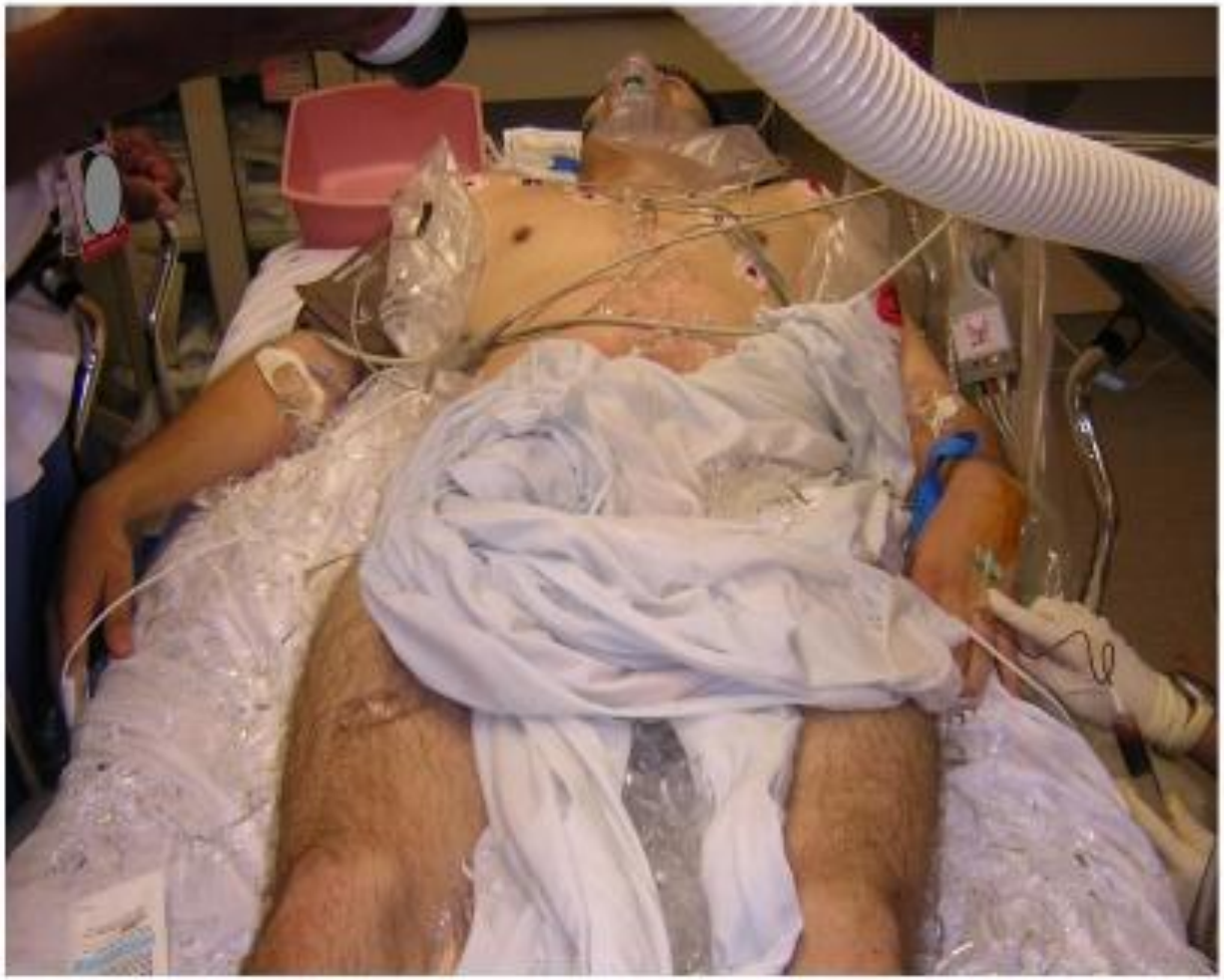
It includes :

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.

# Ice water immersion

# Water ice therapy



## Disadvantages of these methods:

- The cooling rate is less [0.1degree/min.]
  except in peritoneal lavage [0.55 degree/min.]
- Difficult for application in comatosed patient.
- May cause shivering which increase body temp.

# Disadvantages of these methods:

- Direct ice to the skin leads to vasoconstriction .
- Ice enema may cause shock and sudden death.
- Peritoneal lavage may leads to peritonitis.

- Gastric, rectal, and/or bladder lavage with cold isotonic fluids (eg, normal saline that has been iced) have been proposed as additional means of invasive cooling. However, it is not clear that these methods are any more effective than evaporative cooling or cold water immersion alone. Thus, these methods are not routinely employed.

The most effective method of lowering the core body temperature quickly is the use of cardiopulmonary bypass; however, this highly specialized intervention is not rapidly available at most institutions. Newer, less invasive devices such as intravascular cooling catheters have been utilized to rapidly induce therapeutic hypothermia .

# Duration of cooling

- Decreases in core body temperature as measured by rectal temperature generally lag behind the actual drop in core temperature at the hypothalamus. For this reason, cooling measures are generally stopped in heat stroke victims once the core temperature reaches approximately 38ºC to prevent overshoot hypothermia.

# 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 comatosed patient.

  Not cause shivering or peripheral v . c.

  This method must be done in specialized center.

# MEDICAL TREATMENT

- Assessment and management of A,B,C
  Airway,
  Breathing ,
  Circulation

# Primary goal in heat stroke with shock

| Parameter | Goal |
|---|---|
| MAP | ≥ 65 mmHg |
| CVP | 8-12 mmHg (10-16 cmH2O) |
| Urine output | ≥ 0.5 mL/kg/hr |
| SaO2 | ≥ 93 |
| Hct | ≥ 30 |

# Pharmacologic measures

- Antipyretics (e.g., acetaminophen, aspirin, other non steroid alanti inflammatory drugs) have no role in the treatment of heatstroke.
- Antipyretics actually may be harmful in patients who develop hepatic, hematologic, and renal complications because they may aggravate bleeding tendencies.
- Dantrolene is not effective in the treatment of heat stroke.

- Immediate administration of benzodiazepines is indicated in patients with agitation, shivering, or convulsions to stop excessive production of heat.
- In addition, benzodiazepines are the sedatives of choice in patients with sympathomimetic-induced delirium as well as alcohol and sedative drug withdrawals.

# Fluid resuscitation

- Recommendations on the administration of intravenous fluids for circulatory support differ among patient populations and depend on the presence of hypovolemia, preexisting medical conditions, and pre existing cardiovascular disease.
- While patients with heat stroke invariably are volume depleted, cooling alone may improve hypotension and cardiac function by allowing blood to redistribute centrally.
- Aggressive fluid resuscitation generally is not recommended because it may lead to pulmonary edema.

- When pulse rate, blood pressure, and urine output do not provide adequate hemodynamic information, fluid administration should be guided by more invasive hemodynamic parameters, such as central venous pressure(CVP), pulmonary capillary wedge pressure, systemic vascular resistance index(SVRI), and cardiac index(CI)measurements.
- Patients who exhibit a hyperdynamic state(ie,high CI, low SVRI) generally respond to cooling and do not require large amounts of intravenous crystalloid infusions.

- In hypotensive patients who exhibit a hypodynamic response (ie, high CVP, low CI), dobutamine may be the inotrope of choice in these patients.
- Alpha-Adrenergic drugs generally are contraindicated because they cause vasoconstriction and may interfere with heat loss.

- Treatment of rhabdomyolysis involves infusion of large amounts of intravenous fluids (fluid requirements may be as high as 10L),alkalinization of the urine, and infusion of mannitol. Fluid administration is best guided by invasive hemodynamic parameters, and urine output should be maintained at 3mL/kg/h to minimize the risk of renal failure.
- Alkalinization of the urine(to a pHof7.5-8.0) prevents the precipitation of myoglobin in the renal tubules and may control acidosis and hyperkalemia in acute massive musclene crosis.Mannitol may improve renal blood flow and glomerular filtration rate, increase urine output, and prevent fluid accumulation in the interstitial compartment (through its o smotic action) .Once renal failure occurs, dialysis is the only effective therapeutic modality for rhabdomyolysis.

## •Metabolic support

- Muscle necrosis may occur so rapidly that hyperkalemia, hypocalcemia, and hyperphosphatemia become significant enough to cause cardiac arrhythmias and require immediate therapy. In the presence of renal failure, hemodialysis may be necessary.
- Hypertonic dextrose and sodium bicarbonate may be used to shift potassium in to the intracellular environment while more definitive measures (e.g. ,intestinal potassium binding, dialysis) are prepared.

- Hepatic failure is treated conservatively ; liver transplantation should be considered in severe resistantcases:
- Early recognition and treatment of DIC, with replacement of clotting factors, fresh frozen plasma, platelets, and blood.
- ARDS should be treated aggressively , with early mechanical ventilation and positive end-expiratory pressure(PEEP).

# Renal injury

- AKI initially is treated with intravenous fluids, diuretics, and correction of associated acid-base and electrolyte abnormalities. In the setting of rhabdomyolysis, mannitol may be the diuretic of choice because it does not interfere with the acid-base status of the urine, and it may have antioxidant activity. Furosemide may cause tubular acidosis and, therefore, may promote myoglobinde position within the renal tubules. Once renal failure has setin, hemodialysis is the most effective therapy.

# Mordern Interventions for heat stroke

# CritiCool 3-D CureWrap™

# Medivance Arctic Sun™

# Invasive Cooling Methods

- System pumped through 3 balloons coaxially
- temperature probe enabling a 'closed loop' temperature control system

*Bernard, S. et al.. Resuscitation 2013;56:9-13)*

# CoolGard 3000 / Alsius Icy Heat Exchange Catheter

# Intravascular Temperature Management

- •Intravascular Temperature Management (IVTM™) method has been recognized recently as a safe and effective method for controlling core body temperature. Superior, infact, to other cooling methods for achieving and maintaining target temperature.

# How Intravascular Temperature Management Works

- •IVTM technology gets to the core of the temperature issue by managing patient temperature from the inside out. A catheter is inserted in to the central venous system of a critically ill or surgical patient (femoral, subclavian, or internal jugular insertion). The Thermogard Temperature Managament System controls the temperature of the saline circulating through the catheter balloons via remote sensing of the patient's temperature. The patient is cooled or warmed as venous blood passes over each balloon–exchanging heat without infusing saline in to the patient.

# Prognosis

- Indicators of poor prognosis include the following:

-Initial temperature measurement higher than 41°C (106°F) or a temperature higher than 42°C (108°F) or a temperature persisting above 39°C(102°F) despite aggressive cooling measures.

-Coma duration longer than 2 hours

-Severe pulmonary edema

-Delayed or prolonged hypotension

-Lactic acidosis in patients with classic heatstroke

-Acute kidney injury and hyperkalemia

-Aminotransferase levels greater than 1000IU/L during the first 24 hours.

- Morbidity and mortality from heatstroke are related to the duration of the temperature elevation.
- •When therapy is delayed, the mortality rate may be as high as 80%; however, with early diagnosis and immediate cooling, the mortality rate can be reduced to 10%.
- •Mortality is highest among the elderly population, patients with pre existing disease, those confined to a bed, and those who are socially isolated.

# Prevention

- Heatstroke is a preventable illness, and education is the single most important tool for its prevention.
- Recognition of host risk factors and modification of behavior (e.g. , limiting alcohol and drug intake, avoiding use of medications and drugs that interfere with heat dissipation) and physical activity also can prevent heatstroke.

# Take Home Message

- • In hot climate people with elevated body temperature and CNS abnormalities should be treated as victims of heat stroke.
- • Rectal temperature is the most commonly obtained core temperature measurement.
- • Morbidity or mortality are directly related to duration and degree of hyperthermia.
- • The institution of prehospital cooling should not delay timely transportation to definitive care.
- • Proper ICU care can reduce mortality.

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# THANK YOU