# CCM tutorial

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FJFICM FANZCA FHKCA(IC) FHKCA FHKAM

ICU PYNEH

- A 25 year old man who is a construction worker on the roadside, was found to be confused and sent to your Emergency Department.  His medical health was good except with history of psychiatric illness.
- Vitals: E2V4M4. BP 120/80. HR 140/min. RR 32/min. SpO2 93% (FiO2 0.5). Temp 41 °C

# Differential Diagnosis of Hyperthermia

- Hyperthermic syndromes
  - Exertional heat stroke
  - Nonexertional heat stroke
  - Malignant hyperthermia
  - Neuroleptic malignant syndrome
  - Drug-induced hyperthermia
- Infection
  - Meningitis
  - Encephalitis
  - Sepsis

# Differential Diagnosis of Hyperthermia

- Endocrinopathy
  - Thyroid storm
  - Pheochromocytoma
- Central nervous system
  - Hypothalamic bleed
  - Acute hydrocephalus

- More agitated and struggling, SpO2 90% (0.8), RR 38, BP 160/90, GCS E2V2M4 , Temp 41 °C
- P/E: limbs spastic...

# Hyperthermic Syndrome

Table 2. Manifestations of Severe Serotonin Syndrome and Related Clinical Conditions.

| Condition | Medication History | Time Needed for Condition to Develop | Vital Signs | Pupils | Mucosa | Skin | Bowel Sounds | Neuromuscular Tone | Reflexes | Mental Status |
|---|---|---|---|---|---|---|---|---|---|---|
| Serotonin syndrome | Proserotonergic drug | <12 hr | Hypertension, tachycardia, tachypnea, hyperthermia (>41.1°C) | Mydriasis | Sialorrhea | Diaphoresis | Hyperactive | Increased, predominantly in lower extremities | Hyperreflexia, clonus (unless masked by increased muscle tone) | Agitation, coma |
| Anticholinergic "toxidrome" | Anticholinergic agent | <12 hr | Hypertension (mild), tachycardia, tachypnea, hyperthermia (typically 38.8°C or less) | Mydriasis | Dry | Erythema, hot and dry to touch | Decreased or absent | Normal | Normal | Agitated delirium |
| Neuroleptic malignant syndrome | Dopamine antagonist | 1–3 days | Hypertension, tachycardia, tachypnea, hyperthermia (>41.1°C) | Normal | Sialorrhea | Pallor, diaphoresis | Normal or decreased | "Lead-pipe" rigidity present in all muscle groups | Bradyreflexia | Stupor, alert mutism, coma |
| Malignant hyperthermia | Inhalational anesthesia | 30 min to 24 hr after administration of inhalational anesthesia or succinylcholine | Hypertension, tachycardia, tachypnea, hyperthermia (can be as high as 46.0°C) | Normal | Normal | Mottled appearance, diaphoresis | Decreased | Rigor mortis–like rigidity | Hyporeflexia | Agitation |

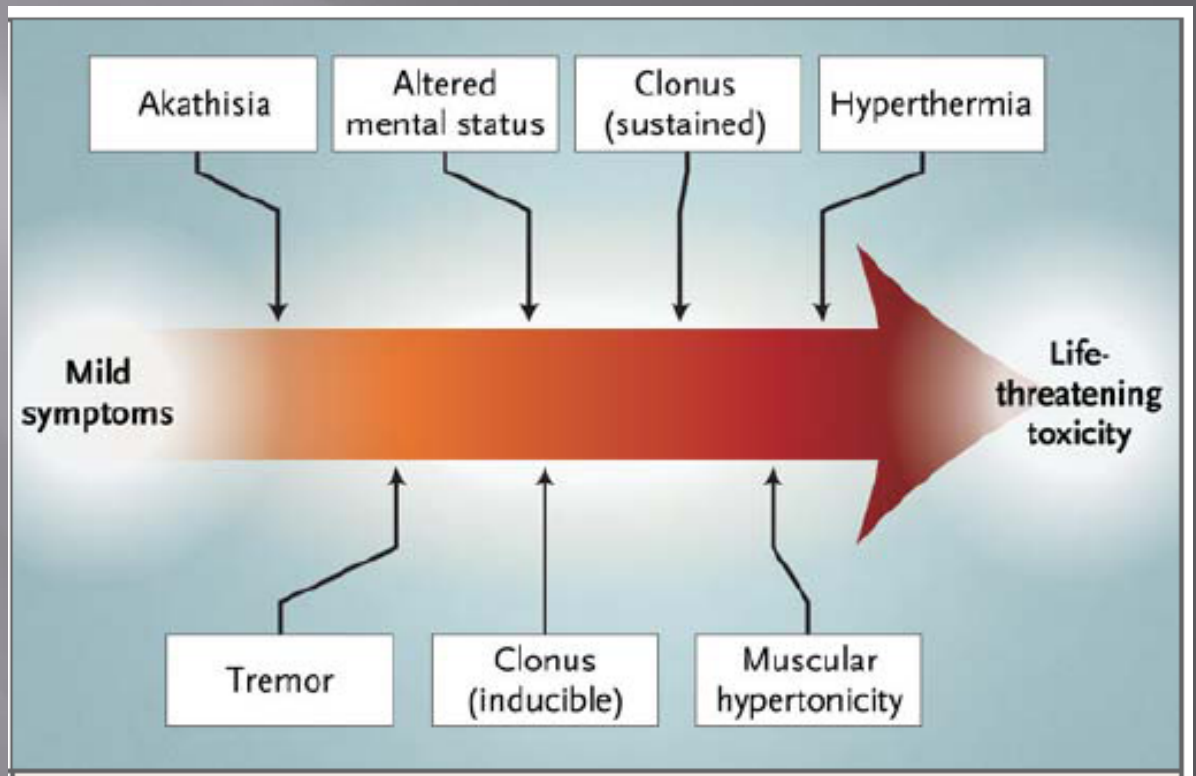


**Figure 1. Spectrum of Clinical Findings.**

Manifestations of the serotonin syndrome range from mild to life-threatening. The vertical arrows suggest the approximate point at which clinical findings initially appear in the spectrum of the disease, but all findings may not be consistently present in a single patient with the serotonin syndrome. Severe signs may mask other clinical findings. For example, muscular hypertonicity can overwhelm tremor and hyperreflexia.

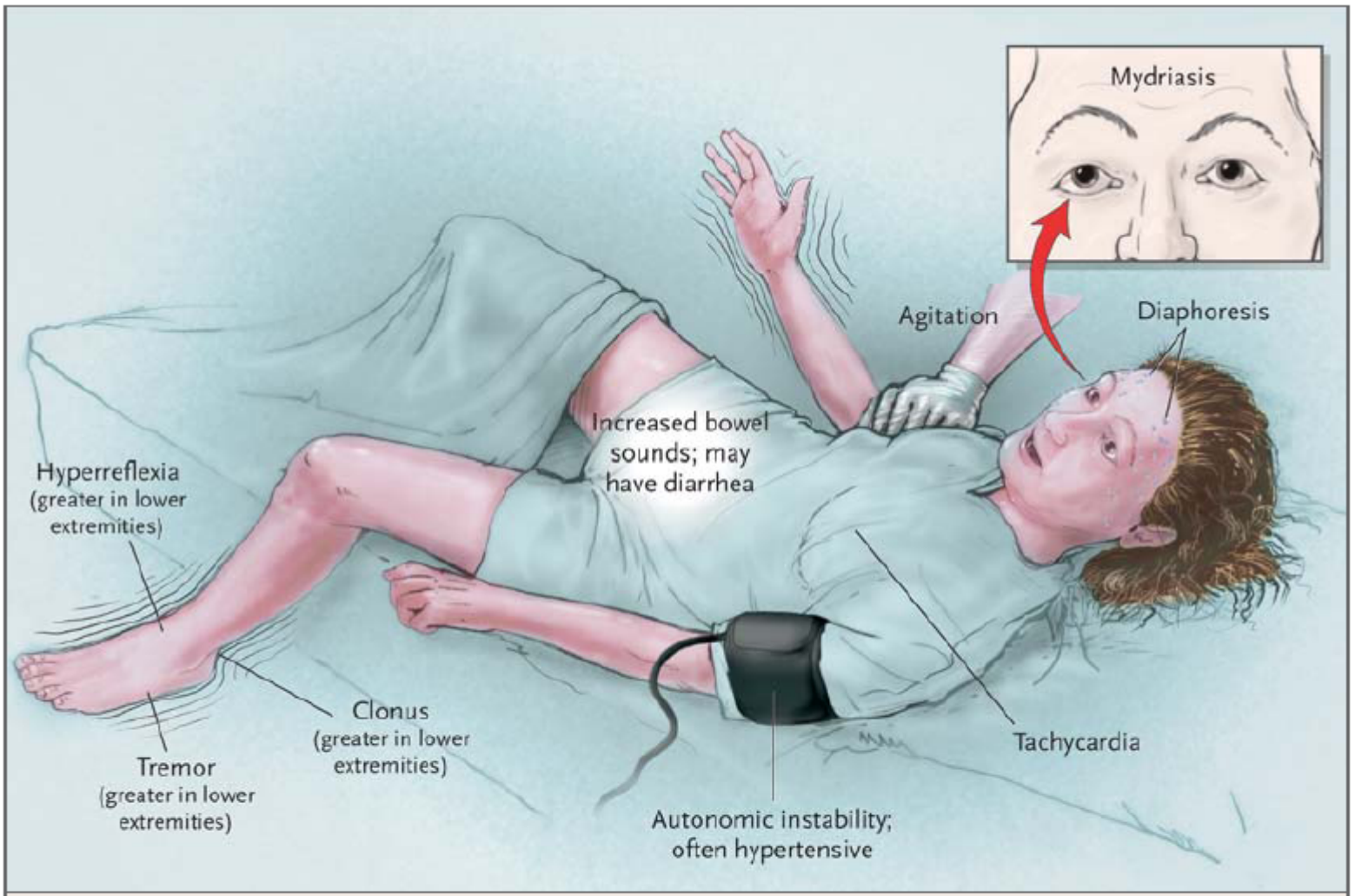


**Figure 2. Findings in a Patient with Moderately Severe Serotonin Syndrome.**

Hyperkinetic neuromuscular findings of tremor or clonus and hyperreflexia should lead the clinician to consider the diagnosis of the serotonin syndrome.

- More agitated and struggling, SpO2 90% (0.8), RR 38, BP 160/90, GCS E2V2M4 , Temp 41 °C
- P/E: limbs spastic...
- Action ?

# Lead II

**Table 72.5** Clinical features of malignant hyperthermia (adapted from Hopkins, 2000[31] with permission)*

| Timing | Clinical signs | Changes in monitored variables | Biochemical changes |
|---|---|---|---|
| Acute | Sustained jaw rigidity after succinylcholine | | |
| | Tachypnoea | Increased minute ventilation | |
| | Rapid exhaustion of soda lime | Rising end-tidal $CO_2$ | Increased $PaCO_2$ |
| | Hot soda lime canister | | Decreased pH |
| | High pulse rate | Tachycardia | |
| | Irregular pulse | Ventricular ectopics | Increased $[K^+]$ |
| | | Peaked T waves on ECG | |
| Intermediate | Patient hot to touch | Rising core body temperature | |
| | Cyanosis | Falling $SpO_2$ | Decreased $PaO_2$ |
| | Dark blood in wound | | |
| | Irregular pulse | Ventricular ectopics | Increased $[K^+]$ |
| | | Peaked T waves on ECG | |
| Late | Generalized muscle rigidity | | |
| | Prolonged bleeding | | |
| | Dark urine | | Increased creatine kinase |
| | Oliguria | | Myoglobinuria |
| | Irregular pulse | Ventricular ectopics | |
| | | Peaked T waves on ECG | Increased $[K^+]$ |
| | Death | | |

# Differential Diagnosis of Hyperthermia

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  - Exertional heat stroke
  - Nonexertional heat stroke
  - Malignant hyperthermia
  - Neuroleptic malignant syndrome
  - Drug-induced hyperthermia
- Infection
  - Meningitis
  - Encephalitis
  - Sepsis

# Toxidrome

Amphetamines
Cocaine and similar drugs
Ecstasy (MDMA, 3,4-methylelenedioxy-methamphetamine)
Lysergic acid diethylamine and similar hallucinogens
Monoamine oxidase inhibitors
- Phenelzine = Nardil
- Tranylcypromine = Parnate

Phencyclidine
Tricyclics
- Amitriptyline = Elavil, Levate
- Clomipramine = Anafranil
- Desipramine = Norpramin
- Doxepin = Sinequan
- Imipramine = Tofranil
- Nortriptyline = Aventyl, Pamelor
- Venlafaxine = Effexor

Serotonin reuptake inhibitors
- Citalopram = Celexa
- Fluoxetine = Prozac
- Fluvoxamine = Luvox

# Heat Disorder

**Table 1.** Glossary of Terms.

| Condition | Definition |
|---|---|
| Heat wave | Three or more consecutive days during which the air temperature is >32.2°C |
| Heat stress | Perceived discomfort and physiological strain associated with exposure to a hot environment, especially during physical work |
| Heat stroke | Severe illness characterized by a core temperature >40°C and central nervous system abnormalities such as delirium, convulsions, or coma resulting from exposure to environmental heat (classic heat stroke) or strenuous physical exercise (exertional heat stroke) |
| Heat exhaustion | Mild-to-moderate illness due to water or salt depletion that results from exposure to high environmental heat or strenuous physical exercise; signs and symptoms include intense thirst, weakness, discomfort, anxiety, dizziness, fainting, and headache; core temperature may be normal, below normal, or slightly elevated (>37°C but <40°C) |
| Hyperthermia | A rise in body temperature above the hypothalamic set point when heat-dissipating mechanisms are impaired (by drugs or disease) or overwhelmed by external (environmental or induced) or internal (metabolic) heat |
| Multiorgan-dysfunction syndrome | Continuum of changes that occur in more than one organ system after an insult such as trauma, sepsis, or heat stroke[24] |

# Heat Stroke

- a form of hyperthermia associated with a systemic inflammatory response leading to a syndrome of multiorgan dysfunction in which encephalopathy predominate

**Table 72.2** Predisposing factors to heat stroke

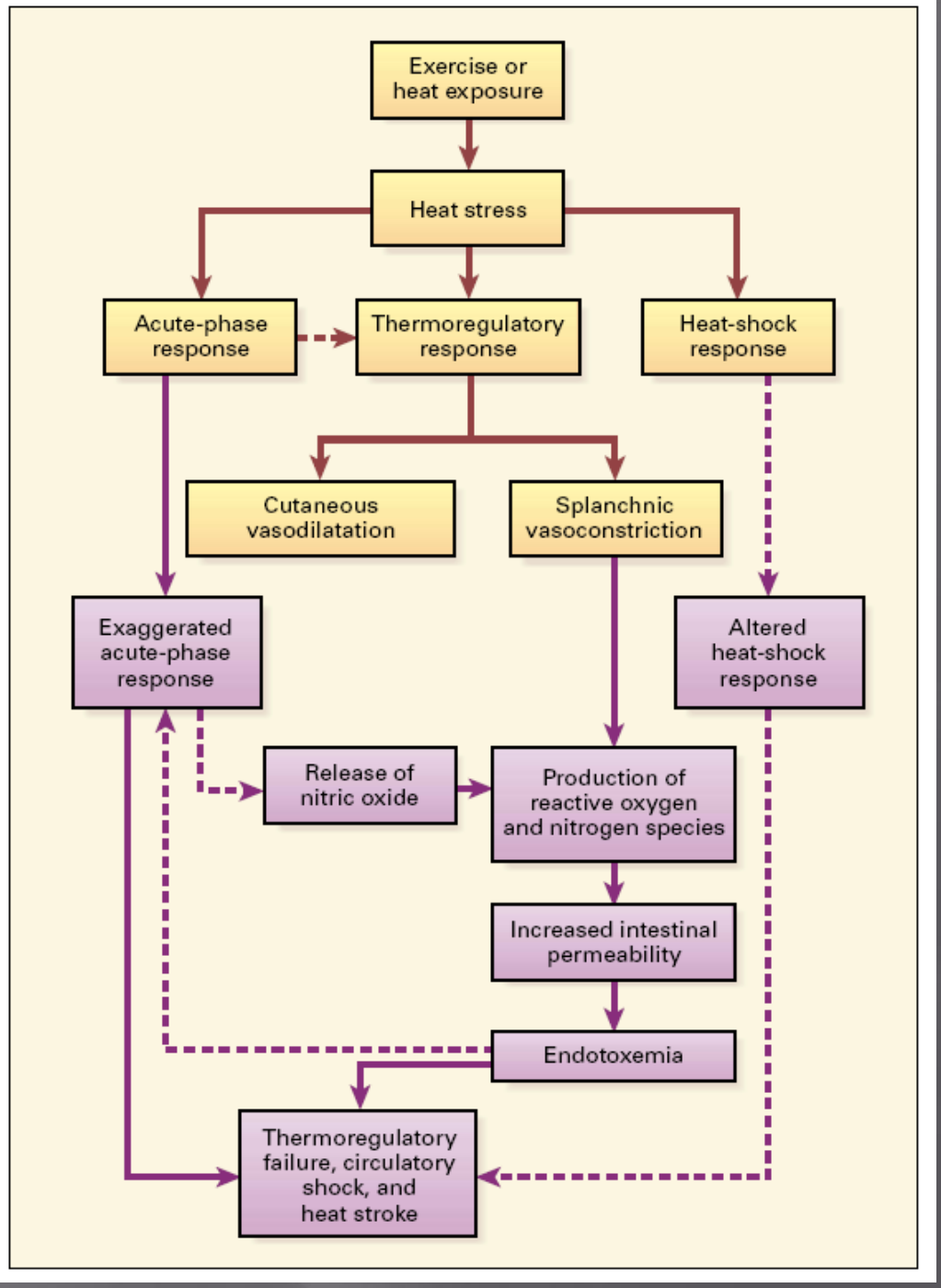
| | |
|---|---|
| Age | Elderly |
| Environmental | High ambient temperature and humidity |
| | Heat waves |
| | Poor ventilation |
| Behavioural | Lack of acclimatization |
| | Salt and water deprivation |
| | Obesity |
| Underlying conditions | Infection/fever |
| | Diabetes |
| | Malnutrition |
| | Alcoholism |
| | Hyperthyroidism |
| | Impaired sweat production |
| | Healed burns |
| | Ectodermal dysplasia |
| | Impaired sweating |
| | Cardiovascular disease |
| | Fatigue |
| | Potassium deficiency |
| Drugs | Anticholinergics |
| | Antiparkinsonians |
| | Antihistamines |
| | Butyrophenones |
| | Phenothiazines |
| | Tricyclics |
| | Diuretics |
| | Sympathomimetics |

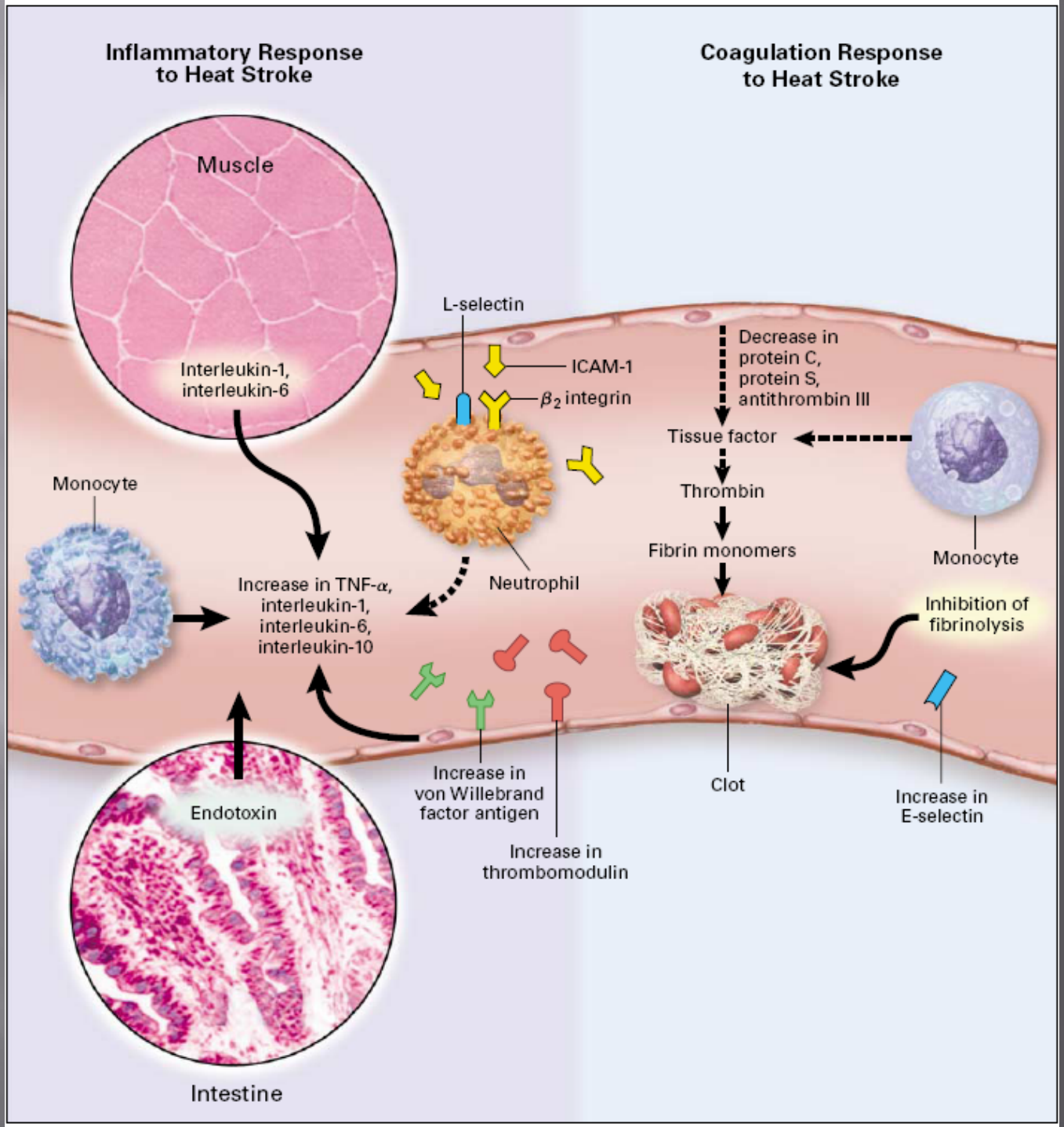
**Table 72.3** Biochemical differences between classic and exertional heat stroke

| | Classic heat stroke | Exertional heat stoke |
|---|---|---|
| Arterial gases | Mixed respiratory alkalosis | Severe metabolic acidosis |
| Serum electrolytes | $Na^+$, $Mg^+$, $Ca^{2+}$, $Mg^{2+}$ are usually normal | Hyperkalaemia |
| | | Hypocalcaemia |
| | Hypophosphataemia | Hyperphosphataemia |
| Blood glucose | Hyperglycaemia | Hypoglycaemia |
| Creatinine kinase | Moderately increased | Markedly increased |
| Hepatic enzymes | Markedly increased | Moderately increased |
| Acute phase proteins | Markedly increased | Moderately increased |

**Table 2.** Effect of Heat Stress and Heat Stroke on Circulating Cytokines, Cytokine Receptors, Growth Factors, and Chemokines.*

| Cytokine or Factor | Heat Stress | | | Heat Stroke | | Reference |
|---|---|---|---|---|---|---|
| | Exercise-induced | Environmental | Therapeutic† | Classic | Exertional | |
| Tumor necrosis factor $\alpha$ | Increased or unchanged | Unchanged | Increased or unchanged | Increased or unchanged | Increased | Bouchama et al.,[11] Espersen et al.,[38] Robins et al.,[39] Camus et al.,[40] Ostrowski et al.,[41] Moldoveanu et al.,[42] Suzuki et al.,[43] Chang[44] |
| Interleukin-1$\beta$ | Increased or unchanged | NA | Increased | Increased or unchanged | Increased | Cannon and Kluger,[37] Robins et al.,[39] Ostrowski et al.,[41] Moldoveanu et al.,[42] Chang,[44] Bouchama et al.[45] |
| Interleukin-2 | Decreased or unchanged | NA | Unchanged | NA | NA | Espersen et al.,[38] Robins et al.[39] |
| Interleukin-6 | Increased | Increased | Increased | Increased | Increased | Robins et al.,[39] Moldoveanu et al.,[42] Suzuki et al.,[43] Chang,[44] Bouchama et al.,[45] Hammami et al.[46] |
| Interleukin-8 | Increased | NA | Increased | NA | NA | Pedersen and Hoffman-Goetz,[22] Robins et al.,[39] Suzuki et al.[43] |
| Interleukin-10 | Increased | Increased | Increased | Increased | NA | Pedersen and Hoffman-Goetz,[22] Robins et al.,[39] Suzuki et al.,[43] Bouchama et al.[47] |
| Interleukin-12 | Increased or unchanged | NA | Unchanged | NA | NA | Pedersen and Hoffman-Goetz,[22] Robins et al.,[39] Suzuki et al.,[43] Akimoto et al.[48] |
| Interleukin-1–receptor antagonist | Increased | NA | NA | NA | NA | Pedersen and Hoffman-Goetz,[22] Ostrowski et al.,[41] Suzuki et al.[43] |
| Soluble interleukin-2 receptor | Increased | NA | NA | Increased | NA | Pedersen and Hoffman-Goetz,[22] Suzuki et al.,[43] Hammami et al.[46] |
| Soluble interleukin-6 receptor | NA | Increased | NA | Decreased | NA | Hammami et al.[49] |
| Soluble tumor necrosis factor receptors (p55 and p75) | Increased | Increased or unchanged | Increased | Increased | NA | Pedersen and Hoffman-Goetz,[22] Hammami et al.[49] |
| Interferon-$\gamma$ | Increased or unchanged | NA | Unchanged | Increased | NA | Pedersen and Hoffman-Goetz,[22] Robins et al.,[39] Suzuki et al.,[43] Bouchama et al.[45] |
| Interferon-$\alpha$ | Increased or unchanged | NA | Unchanged | NA | NA | Suzuki et al.,[43] Viti et al.[50] |
| Granulocyte colony-stimulating factor | Increased | NA | Increased | NA | NA | Pedersen and Hoffman-Goetz,[22] Robins et al.,[39] Suzuki et al.[43] |
| Macrophage-inhibitor proteins | Increased | NA | Unchanged | NA | NA | Pedersen and Hoffman-Goetz,[22] Robins et al.[39] |


Exercise or heat exposure
Heat stress
Acute-phase response
Thermoregulatory response
Heat-shock response
Cutaneous vasodilatation
Splanchnic vasoconstriction
Exaggerated acute-phase response
Altered heat-shock response
Release of nitric oxide
Production of reactive oxygen and nitrogen species
Increased intestinal permeability
Endotoxemia
Thermoregulatory failure, circulatory shock, and heat stroke


Inflammatory Response to Heat Stroke
Coagulation Response to Heat Stroke
Muscle
Interleukin-1, interleukin-6
L-selectin
ICAM-1
$\beta_2$ integrin
Neutrophil
Monocyte
Increase in TNF-α, interleukin-1, interleukin-6, interleukin-10
Endotoxin
Intestine
Increase in von Willebrand factor antigen
Increase in thrombomodulin
Decrease in protein C, protein S, antithrombin III
Tissue factor
Thrombin
Fibrin monomers
Clot
Monocyte
Inhibition of fibrinolysis
Increase in E-selectin

# Presentation

- Brain dysfunction:
  - usually severe but may be subtle, inappropriate behavior or impaired judgment to delirium or frank coma
  - Seizures may occur, especially during cooling

# Presentation

- tachycardia and hyperventilation
- Twenty-five percent of patients have hypotension
- Hypercalcemia and hyperproteinemia
- rhabdomyolysis, hyperphosphatemia, hypocalcemia, and hyperkalemia may be important events after complete cooling

# Presentation

- Multiorgan-dysfunction syndrome:
  - encephalopathy,
  - rhabdomyolysis, acute renal failure,
  - acute respiratory distress syndrome,
  - myocardial injury,
  - hepatocellular injury, intestinal ischemia or infarction, pancreatic injury,
  - hemorrhagic complications, especially disseminated intravascular coagulation, with pronounced thrombocytopenia

**TABLE 3.** MANAGEMENT OF HEAT STROKE.*

| CONDITION | INTERVENTION | GOAL |
|---|---|---|
| **Out of hospital** | | |
| Heat stress (due to heat wave, summer heat, or strenuous exercise), with changes in mental status (anxiety, delirium, seizures, or coma) | Measure the patient's core temperature (with a rectal probe) | Diagnose heat stroke† |
| | If the core temperature is >40°C, move the patient to a cooler place, remove his or her clothing, and initiate external cooling‡: cold packs on the neck, axillae, and groin; continuous fanning (or opening of the ambulance windows); and spraying of the skin with water at 25°C to 30°C | Lower the core temperature to <39.4°C, promote cooling by conduction, and promote cooling by evaporation |
| | Position an unconscious patient on his or her side and clear the airway | Minimize the risk of aspiration |
| | Administer oxygen at 4 liters/min | Increase arterial oxygen saturation to >90% |
| | Give isotonic crystalloid (normal saline) | Provide volume expansion |
| | Rapidly transfer the patient to an emergency department | |
| **In hospital** | | |
| Cooling period | Confirm diagnosis with thermometer calibrated to measure high temperatures (40°C to 47°C) | |
| Hyperthermia | Monitor the rectal and skin temperatures; continue cooling | Keep rectal temperature <39.4°C§ and skin temperature 30°C–33°C |
| Seizures | Give benzodiazepines | Control seizures |
| Respiratory failure | Consider elective intubation (for impaired gag and cough reflexes or deterioration of respiratory function) | Protect airway and augment oxygenation (arterial oxygen saturation >90%) |
| Hypotension¶ | Administer fluids for volume expansion, consider vasopressors, and consider monitoring central venous pressure | Increase mean arterial pressure to >60 mm Hg and restore organ perfusion and tissue oxygenation |
| Rhabdomyolysis | Expand volume with normal saline and administer intravenous furosemide, mannitol, and sodium bicarbonate | Prevent myoglobin-induced renal injury: promote renal blood flow, diuresis, and alkalization of urine |
| | Monitor serum potassium and calcium levels and treat hyperkalemia | Prevent life-threatening cardiac arrhythmia |
| After cooling | Supportive therapy | Recovery of organ function |
| Multiorgan dysfunction | | |

*Data are from Knochel and Reed,[1] Graham et al.,[80] Wyndham et al.,[81] Weiner and Khogali,[82] Al-Aska et al.,[83] White et al.,[84,85] and Bouchama et al.[86]

# Cooling

- Rapid transfer of heat from the core to the skin and from the skin to the external environment
- transfer of heat from the core to the skin is facilitated by active cutaneous vasodilatation
- aimed at accelerating the transfer of heat from the skin to the environment without compromising the flow of blood to the skin

# COOLING WITH ICE

# Hypothermia technique

- Cooling initiated as soon as possible
- Cooling techniques:
  - External cooling methods
    - Simple but slow
    - Use of cooling blankets
    - Ice packs to groin, axillae, neck
    - Wet towels
    - Fanning

- Internal cooling
  - IV infusion of crystalloid at 4’C
  - Peritoneal lavage
  - Extracorporeal cooling
  - Intravascular cooling catheter

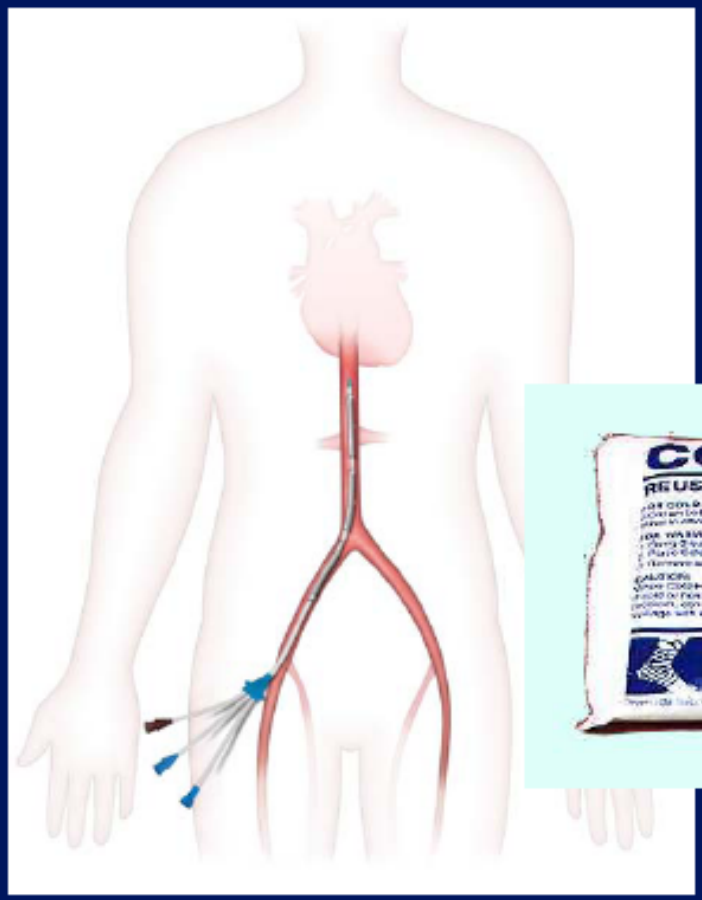
**Table 5** Methods for inducing hypothermia

| Method | Basic mechanism | Manufacturer |
|---|---|---|
| Peripheral cooling | | |
| Fans[a] | Convection | - |
| Air-circulating cooling blankets | Convection | "Polar Air" and "Bair Hugger", Augustine Medical, Eden Prairie, USA |
| Ice packs | Conduction | - |
| Water-circulating cooling blankets | Conduction | "Blanketrol II hyper-hypothermia", Cincinnati Sub-Zero, Cincinnati, USA |
| Immersion | Conduction | - |
| Specially designed beds | Conduction | "TriaDyne", Kinetic Concepts International, San Antonio, USA |
| Cooling caps | Conduction | "Frigicap" |
| Water and alcohol sprays | Evaporation | - |
| Sponge baths | Evaporation | - |
| Exposure of skin | Radiation | - |
| Core cooling | | |
| Intravascular catheters | Conduction | "Celcius Control", Innercool therapies, San Diego, USA<br>"CoolLine" and "Coolgard", Alsius, Irvine, USA<br>"SetPoint" and "Reprieve", Radiant medical, Redwood City, USA |
| Infusion of ice-cold (4°C) fluids | Conduction | - |
| Extracorporeal circulation | Conduction | Various devices |
| Antipyretic agents | Effect on CNS | Various drugs |

[a] Use of fans to cool patients may be associated with increased infection risks

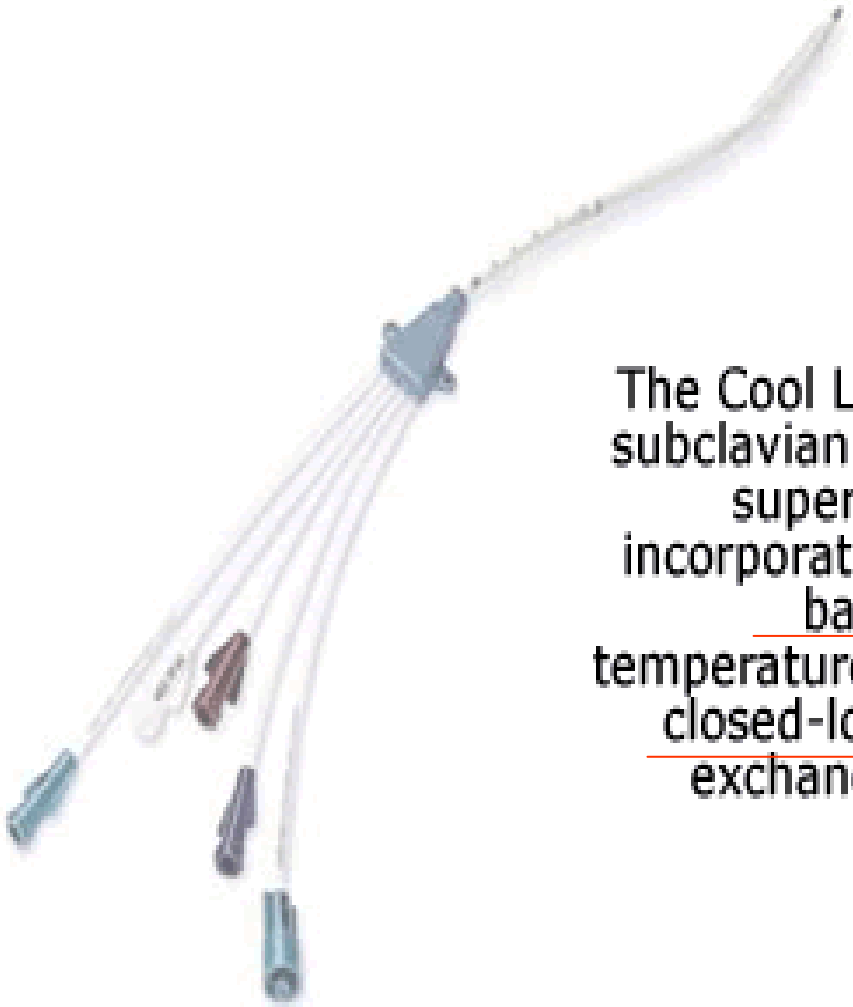
# How to cool

## Ice packs, cooling blankets, catheters…

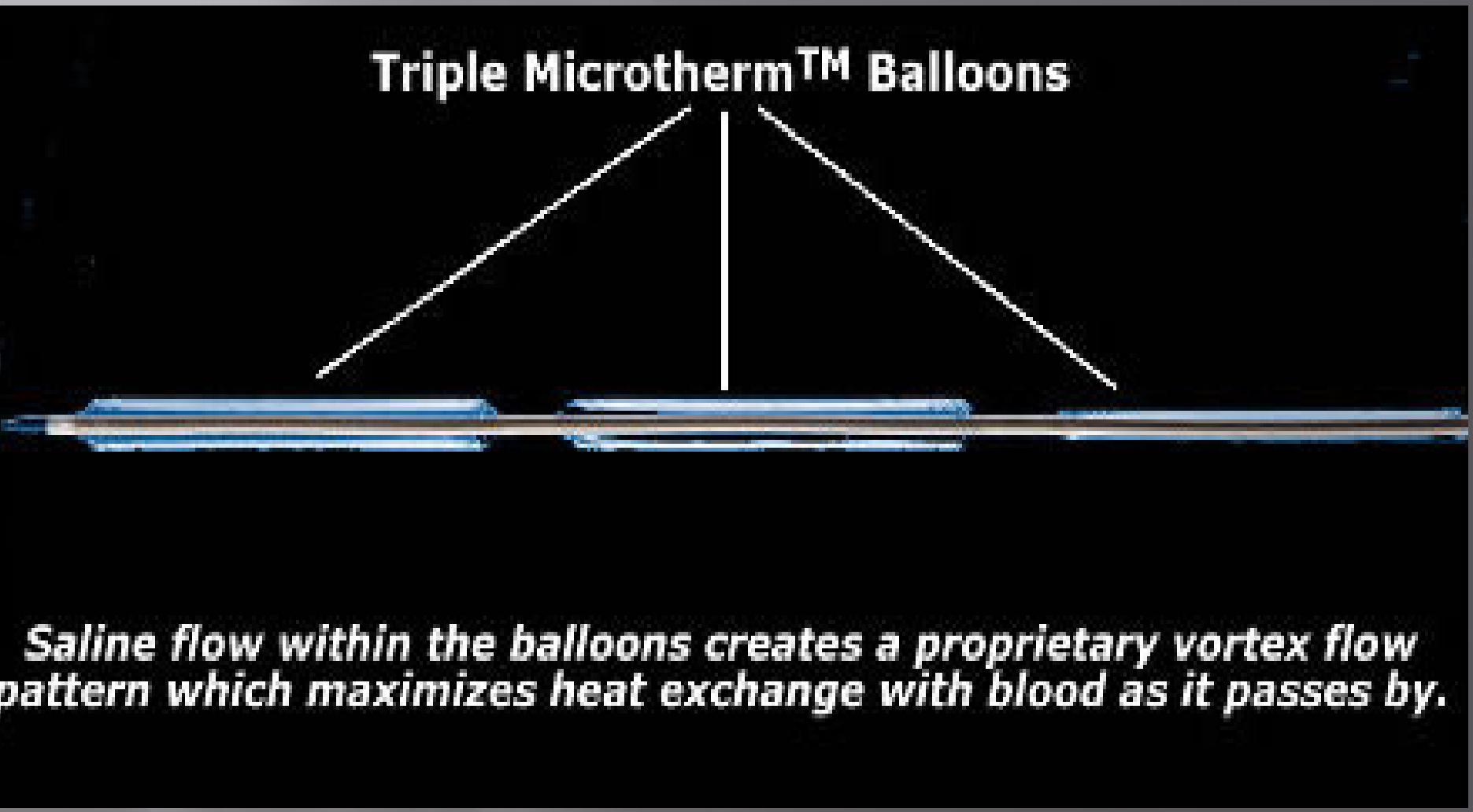


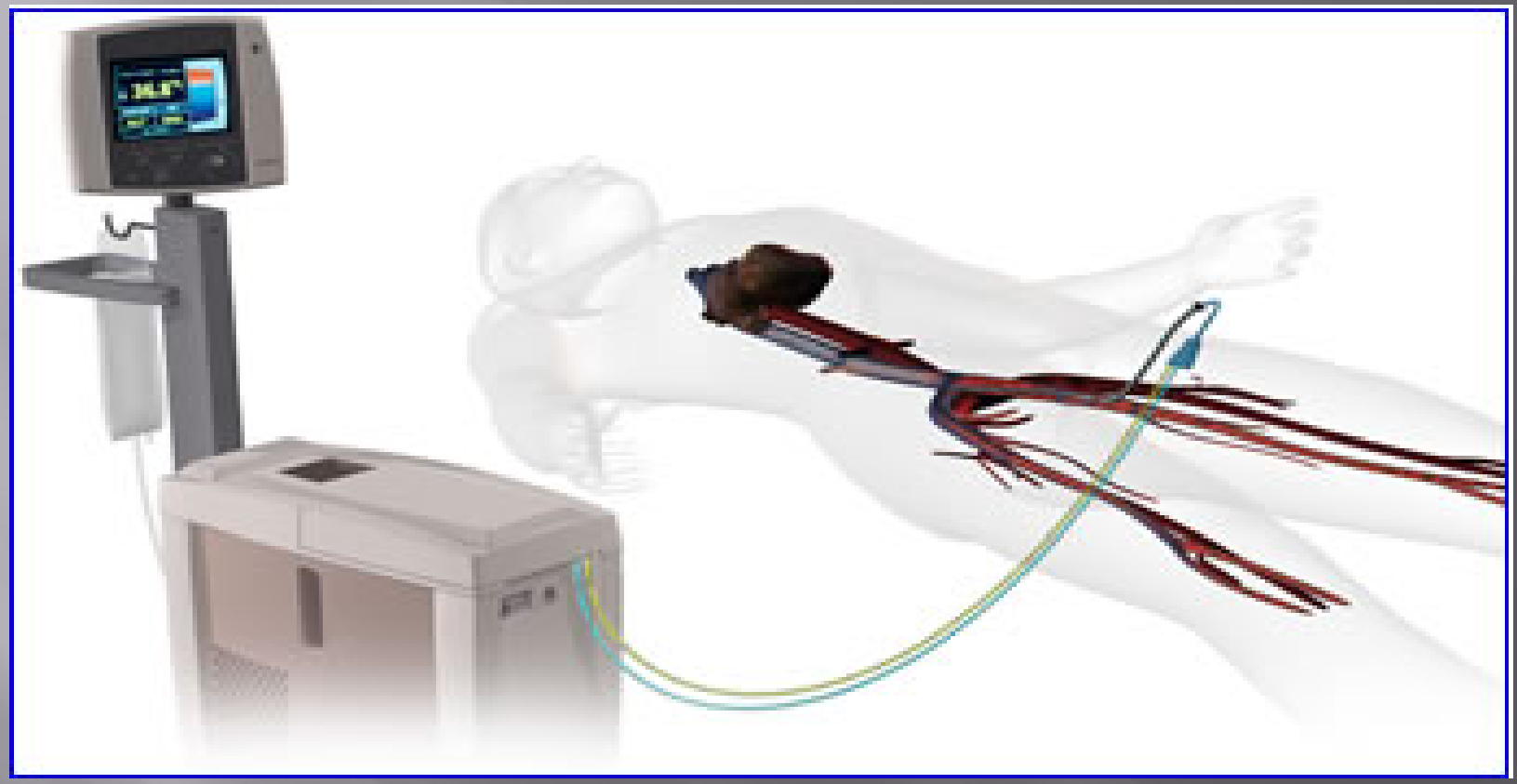
# Medivance "Arctic Sun"

# The LRS ThermoSuit® System



The Cool Line™ catheter is inserted into the subclavian or jugular vein and resides in the superior vena cava. The Cool Line incorporates two proprietary, MicroTherm™ balloons which have sterile, temperature-controlled saline flowing within a closed-loop design, enabling direct heat exchange with the central circulation.

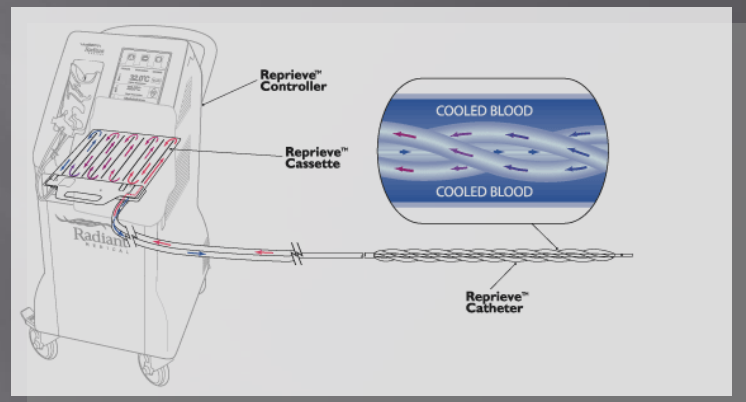

Triple Microtherm™ Balloons
Saline flow within the balloons creates a proprietary vortex flow
pattern which maximizes heat exchange with blood as it passes by.



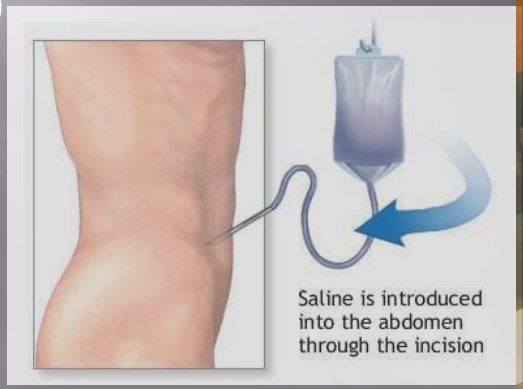
Intravascular cooling catheter connected to Thermal Regulation System e.g. CoolGard 3000

# Internal cooling techniques

Cooled IV fluid (LVICF)




Intravascular heat exchange device




Peritoneal, pleural or gastric lavage

Extracorporeal cooling (cardiopulmonary bypass, hemodialysis)

- You are asked to review an 80 year old woman in the emergency department who has presented with a depressed conscious state. She has ischaemic heart disease and paroxysmal atrial fibrillation. Her medication includes aspirin, metoprolol, and amiodarone. On examination she has a temperature of 29.50 C she is drowsy with a GCS of 7, with a pulse of 50 bpm and a BP 70/40.

| | | | |
|---|---|---|---|
| Sodium | 120 | mmol/L | (137 -145) |
| Potassium | 4 | mmol/L | (3.5 – 5.0) |
| Urea | 6 | mmol/L | (2.5 – 7.5) |
| Creatinine | 90 | micromol/L | (50 - 100) |
| Measured Osmolality | 255 | mmol/kg | (280 - 300) |
| Glucose | 3 | mmol/L | 3.5 – 6.0 |
| CK | 1000 | U/L | (20 - 200) |
| Cholesterol | 7.2 | mmol/L | (3.0-5.5) |

**Decreased heat production**

Endocrinologic failure
- Hypothyroidism
- Hypopituitarism
- Hypoadrenalism

Insufficient fuel
- Hypoglycemia
- Malnutrition
- Extreme physical exertion

Neuromuscular physical exertion
- Age extremes
- Impaired shivering
- Inactivity
- Lack of adaptation

**Impaired thermoregulation**

Peripheral failure
- Neuropathies
- Acute spinal cord transection
- Diabetes

Central nervous system failure or neurologic abnormalities
- Pharmacologic causes
- Metabolic causes
- Toxins
- Cerebrovascular accident
- Central nervous system trauma
- Neoplasm
- Degenerative disease

**Increased heat loss**

Induced vasodilation
- Pharmacologic
- Toxin-induced

Dermatologic causes
- Burns
- Dermatitis

Iatrogenic causes
- Exposure
- Cold infusions
- Emergency deliveries

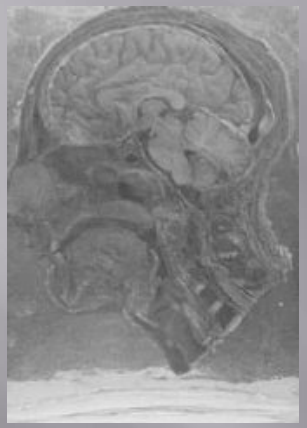
Environmental causes
- Immersion
- Nonimmersion

**Miscellaneous associated clinical states**
- Multisystem trauma
- Shock
- Cardiopulmonary disease
- Systemic acidoses
- Infections — bacterial, viral, parasitic
- Carcinomatosis
- Vascular insufficiency
- Pancreatitis
- Uremia
- Recurrent or episodic hypothermia

Danzl D and Pozos R. N Engl J Med 1994;331:1756-1760

# BASIC SCIENCE

# Physiologic effects of IH (1)

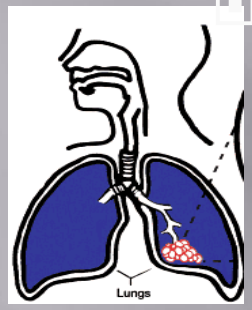


- **CNS:**
- Damage + apoptosis Reduces the CMRO2 by 6% for every 1'C reduction in brain temp > 28'C
- Suppress many of the chemical reactions assn with reperfusion injury
  - Free radical production
  - Excitatory amino acid release
  - Calcium shifts, Neuroexcitatory cascade
- Relative improvement in $O_2$ supply to ischemic areas of brain;
- ↓ICP;
- Anticonvulsant.

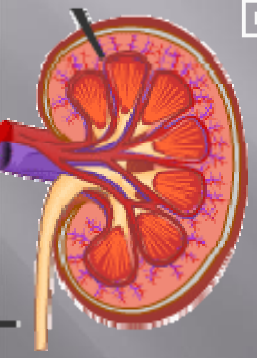
# Physiologic effects of IH (2)

- **CVS:**
  - < 35'C: bradycardia, decrease C.O
  - <33'C: ECG changes of increase PR interval, widening QRS, increase QT
  - <32'C: mild arrhythmia in some patients
  - < 28-30'C: marked increase risk of tachyarrhythmia
  - J or Osborn wave below 33 C– not pathogonomic but seen in most hypothermic patients

# Physiologic effects of IH (3)

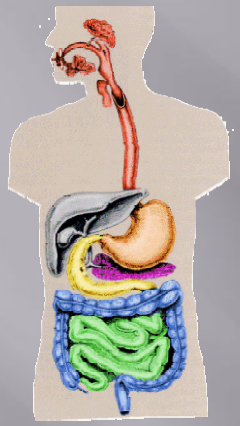



- **Respiratory system:**
  - ↓MV in response to ↓metabolic rate.
  - Left shift in oxyhemoglobin curve impairing oxygen delivery

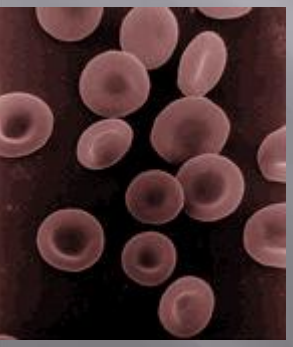


- **Renal system:**
  - Diuresis (↓reabsorption of solute in ascending limb);
  - ↓Serum K (shifted into cells);
  - ↓$PO_4$.

# Physiologic effects of IH (4)



- **Gastrointestinal system:**
  - ↓Gut motility ⇒ Delay enteral feeding;
  - Mild pancreatitis
  - Increase liver enzyme, suppressed liver functions
  - Gastric submucosal hemorrhage, duodenal ulceration and perforation



- **Hematologic system:**
- ↓ WCC numbers & function ⇒ ↑incidence of sepsis;
- ↓ Platelet numbers & function;
- Prolongs clotting.

# Physiologic effects of IH (5)

- Metabolic:
  - Decrease O2 consumption
  - Decrease CO2 production
  - Decrease metabolism
  - Increase fat metabolism→ increase glycerol, FFA, ketonic acid, lactate
  - Metabolic acidosis

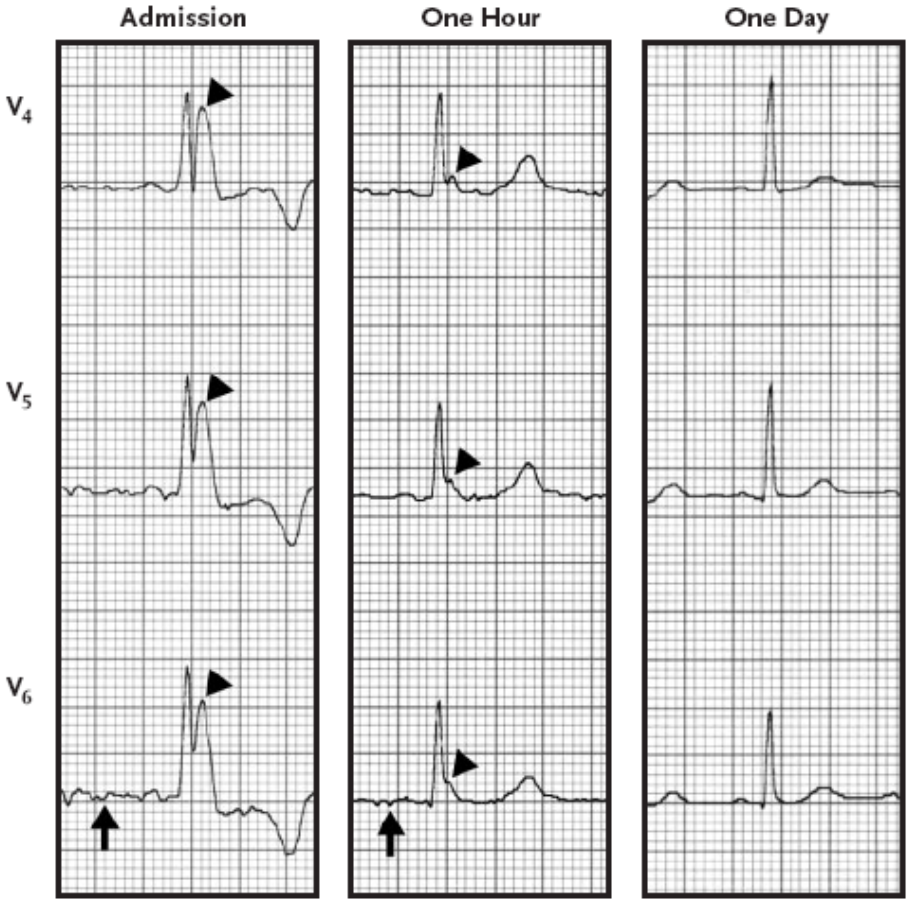
# Physiologic effects of IH (6)

- Pharmacokinetc:
  - Altered clearance of various medications

# Adverse Systemic Effects of Hypothermia

| Level | Core Temperature | Adverse Systemic Effects |
|---|---|---|
| Mild | >32°C<br>(>89.6°F) | Confusion<br>Shivering<br>Catacholamine release<br>Peripheral vasoconstriction<br>Cold-induced diuresis |
| Moderate | 28-32°C<br>(82.4-89.6°F) | Stupor<br>Ventricular arrhythmias<br>Hypotension<br>Coagulopathies<br>Immunosuppression |
| Severe | 20-28°C<br>(68-82.4°F) | Coma<br>Metabolic acidosis<br>Ventricular fibrillation<br>Severe hypotension<br>Hyperkalemia |
| Profound | <20°C<br>(<68°F) | Mimic brain death<br>Asystole<br>Flat electroencephalogram |

Source: Hammer MD, Krieger DW, Cleveland Clinic J. Med. 69:10, 2002




| | | | |
|---|---|---|---|
| Temperature (C°) | 24.1 | 29.4 | 36.6 |
| Heart rate (beats/min) | 50 | 70 | 98 |
| QRS interval (msec) | 184 | 119 | 71 |
| QTc interval (msec) | 516 | 502 | 403 |

# Management

# Initial stabilization

- Prevent additional evaporative heat loss by removing wet garments and insulating the victim from further environmental exposures
- Do not delay urgent procedures, such as intubation and insertion of vascular catheters, but perform them gently while closely monitoring cardiac rhythm. These patients are prone to develop ventricular fibrillation (VF)

# Resuscitation

- ventricular tachycardia (VT) or VF is present, defibrillation should be attempted
- If VF is detected, it should be treated with 1 shock then immediately
- If the patient does not respond to 1 shock, further defibrillation attempts should be deferred, and the rescuer should focus on continuing CPR and rewarming the patient to a range of 30˚C to 32˚C (86˚F to 89.6˚F) before repeating the defibrillation attempt

# Resuscitation

- aggressive active core rewarming techniques as the primary therapeutic modality
- severely hypothermic victim, cardioactive medications can accumulate to toxic levels in the peripheral circulation if given repeatedly
- IV drugs are often withheld if the victim's core body temperature is 30°C

# Resuscitation

- volume administration because the vascular space expands with vasodilation
- look for and treat underlying conditions
- For patients with a core body temperature 30˚C and cardiac arrest, with or without return of spontaneous circulation, these patients may benefit from prolonged CPR and internal warming

# Resuscitation

- If the core body temperature is 30°C, IV medications may be administered but with increased intervals between doses
- Warmed humidified oxygen (42°C to 46°C)
- warmed IV fluids (normal saline) at 43°C
- peritoneal lavage with warmed fluids
- pleural lavage with warm saline through chest tubes
- extracorporeal blood warming with partial bypass and cardiopulmonary bypass

# Re-warming

# Re-warming

- Active external rewarming uses heating methods or devices (radiant heat, forced hot air, warmed IV fluids, warm water packs)
- careful monitoring for hemodynamic changes and tissue injury from external heating devices
- "afterdrop effect"
- internal warming (peritoneal lavage, esophageal rewarming tubes, cardiopulmonary bypass, extracorporeal circulation

**Table 2** Rewarming Methods

| Category | Methods | Comments | Rewarming Rate (°C/h) |
|---|---|---|---|
| Passive external | Blankets | Including head and neck, reduces evaporative heat loss, unsuccessful if there is loss of shivering | 0.5-4 |
| | Humidifier inspired air | Including head and neck, reduces evaporative heat loss, unsuccessful if there is loss of shivering | Variable |
| Active external | Forced heated air | Risk of temperature after-drop and rewarming hypotension | 1-2.5 |
| | Warm blankets | Risks of burns, temperature after-drop, and rewarming hypotension | Variable |
| | Warm water immersion | Difficult to monitor patient, risk of temperature after-drop and rewarming hypotension | 2-4 |
| Active internal | Warm (42°C) humidified air | Low heat transport capacity | 0.5-1.2 |
| | Warm (42°C) intravenous fluids | Especially useful in the resuscitation of hypothermic trauma victims, rapid infusion maximizes heat delivery | Variable |
| | Body cavity lavage with warm fluid (gastric, bladder, colon, pleural, peritoneal) | Limited data, risk of mucosal injury, risk if aspiration with gastric lavage | Variable |
| Extracorporeal | Hemodialysis and hemofiltration | Widely available, rapid initiation, requires adequate blood pressure | 2-3 |
| | Continuous arteriovenous rewarming | Rapid initiation, trained perfusionist not required, less available, requires adequate blood pressure | 3-4 |
| | Cardiopulmonary bypass | Provides full circulatory support, allows oxygenation, less available, requires trained perfusionist, delays in initiation | 7-10 |

# Re-warming

- Hypothermia with a perfusing rhythm:
  - –Mild (34°C): passive rewarming
  - –Moderate (30°C to 34°C): active external rewarming
  - –Severe (30°C): active internal rewarming; consider extracorporeal membrane oxygenation

# Re-warming

- Patients in cardiac arrest will require CPR with some modifications of conventional BLS and ACLS care and will require active internal rewarming

  –Moderate (30°C to 34°C): start CPR, attempt defibrillation, establish IV access, give IV medications spaced at longer intervals, provide active internal rewarming

  –Severe (30°C): start CPR, attempt defibrillation once, withhold medications until temperature 30°C , provide active internal rewarming