

Heatstroke and Hyperthermia

BASICS

DEFINITION

- An excessively high body temperature (105-110° F, 41-43° C) that can be differentiated into [fever](#) and primary hyperthermia
- Pyrogenic hyperthermia or fever--fully functional thermoregulatory mechanisms are present. Pyrogens act on hypothalamus via interleukin-1 and prostaglandins to raise the temperature set point to a higher level (e.g., septicemia).
- Nonpyrogenic hyperthermia --normal heat dissipating mechanisms cannot compensate for excessive heat producing mechanisms or heat load, and the temperature rises above the hypothalamic temperature set point (e.g., animals with heatstroke, excessive exercise, seizures, [tetanus](#), thyrotoxicosis, and malignant hyperthermia during anesthesia).

Pathophysiology

Severe hyperthermia may cause generalized cellular necrosis associated with heat denaturation of cellular proteins, enzymes, and cell membranes. The critical temperature for organ failure is 109° F.

Systems Affected

- Nervous--neuronal injury and cerebral edema
- Cardiovascular-- hemoconcentration, hypovolemia, and myocardial necrosis
- Gastrointestinal--mucosal necrosis, bacterial translocation, and endotoxemia
- Hepatobiliary--toxic thermal damage
- Renal/urologic--tubular damage and [acute renal failure](#)
- Hemic/lymph/immune--[disseminated intravascular coagulation](#)
- Musculoskeletal-- rhabdomyolysis

Geographic Distribution

More commonly observed in warmer climates

Species Dogs and cats

Breed Predislection

- Breeds with a thick hair coat possibly more commonly affected
- Brachycephalic breeds

Mean Age and Range

All ages can be affected



SIGNS

Historical Findings

- Underlying cause for failure to dissipate heat (e.g., locked in a car, hot afternoon, and grooming accident)
- History of laryngeal [paralysis](#), upper respiratory disease, neurologic disease, or cardiovascular disease

Physical Examination Findings

- [Panting](#)
- [Hypersalivation](#)
- Hyperthermia
- Dehydration
- Congested mucous membranes
- Tachycardia (fast heart rate)
- Additional signs depend on the severity and duration of hyperthermia:
- Tachyarrhythmias
- [Shock](#)
- Respiratory distress or arrest
- Hemorrhagic vomiting and diarrhea (bloody)
- Petechiation
- [Melena](#)
- [Oliguria](#) or [anuria](#) (not urinating)
- Seizures, [stupor](#), and [coma](#)

CAUSES

- Excessive environmental heat and humidity (e.g., dogs confined in cars and grooming accidents)
- Exercise
- Toxicosis (e.g., [strychnine](#), organophosphates, chlorinated hydrocarbons, metaldehyde, and salicylates)
- Anesthesia (i.e., malignant hyperthermia, an inherited muscle abnormality causing a rapid rise in intracellular calcium concentration with subsequent hyperthermia in response to certain inhalation anesthetics)

RISK FACTORS

- Previous episodes of heatstroke
- Age extremes
- Poor acclimatization to heat
- [Hyperthyroidism](#)
- Poor physical conditioning
- Administration of drugs that compromise the patient's ability to dissipate heat (e.g., respiratory depressants) or raise the metabolic rate



- Underlying cardiovascular, neurologic, or upper respiratory disease (e.g., laryngeal paralysis)
- Brachycephalic breeds because of upper airway obstruction associated with conformation
- Salt or water depletion
- [Obesity](#)
- High heat and humidity; poor air circulation in environment
- Thick hair coat

DIAGNOSIS

CBC/BIOCHEMISTRY/URINALYSIS

- CBC abnormalities may include a stress leukogram, [thrombocytopenia](#), and hemoconcentration.
- Biochemistry profile may reveal [azotemia](#), high lactic dehydrogenase, high serum [alkaline phosphatase](#), high activities of alanine and aspartate transaminase, [hypernatremia](#), [hyperchloremia](#), [hyperglycemia](#), [hypercalcemia](#), [hypophosphatemia](#), and [hypokalemia](#).
- Urinalysis may show concentrated urine, [proteinuria](#), cylindruria, and, occasionally, [myoglobinuria](#).

OTHER LABORATORY TESTS

- Blood gas analysis may show a mixed acid/base disorder--respiratory alkalosis due to excessive [panting](#) and [metabolic acidosis](#) due to [shock](#) and excessive muscular activity.
- Coagulation profile may show abnormalities pointing to the development of [disseminated intravascular coagulation](#) (i.e., prolonged prothrombin time [PT] and partial thromboplastin time [PTT], low fibrinogen, high fibrin degradation products [FDP], and thrombocytopenia).

IMAGING

Thoracic radiographs may identify underlying cardiovascular or respiratory disease.

TREATMENT

- Immediate reversal of hyperthermia! The key to recovery is early recognition and treatment.
- Have the owner spray the dog with water and cool with electric fan before and during the transport to the clinic. In emergency room, continue cold water treatment, and apply alcohol on foot pads, axilla, and groin. Stop cooling when temperature has reached 103° F to avoid a precipitous drop in temperature. Ice baths are not recommended (shivering and vasoconstriction lessen heat loss).
- Stabilize vital signs--intubate comatose animals, give oxygen to cyanotic dogs, correct hypovolemia and acid/base imbalances, treat cerebral edema.
- Detect and treat possible complications (e.g., acute renal failure and disseminated intravascular coagulation).
- Remove predisposing factors.



INPATIENT VERSUS OUTPATIENT

Severe hyperthermia/heatstroke often poses an acute, life-threatening emergency situation. Most patients require intensive care for several days to weeks depending on how quickly the animal recovers.

MEDICATIONS

DRUGS AND FLUIDS

- IV Fluid and electrolyte replacement/shock therapy--0.45% saline with 2.5% dextrose at 50-80 ml/kg in the first hour, with additional fluids administered according to the animal's thermodynamic, metabolic, and circulatory status to maintain renal output
- Acute renal failure--[dopamine](#) infusion (2-4 mcg/kg/min IV) to increase renal blood flow, [furosemide](#) (2 mg/kg q8h), closed urine collection system, and central venous pressure monitoring
- Cerebral edema ([stupor/coma](#))-- [mannitol](#) (0.5 g/kg over 20 min IV; do not use during initial resuscitation efforts!) and [dexamethasone](#) sodium phosphate (1-2 mg/kg IV) or [prednisolone](#) sodium succinate (10-20 mg/kg IV)
- Ventricular arrhythmias--[lidocaine](#) bolus (2 mg/kg IV) followed by infusion (25-75 mcg/kg/min IV)
- Metabolic acidosis--bicarbonate ($0.3 \times \text{BW}\{\text{kg}\} \times \text{base deficit}$, give half as a bolus; alternatively, add 2-3 meq/kg to saline infusion)
- Disseminated intravascular coagulation--fresh frozen plasma (20 ml/kg) and heparin (50-75 U/kg SC q6h)
- Hemorrhagic diarrhea/bacterial translocation--broad-spectrum antibiotics
- Seizures--[diazepam](#) (0.5 mg/kg IV) and/or [phenobarbital](#) (2 mg/kg)
- Shivering or muscle rigidity--diazepam
- Anxiety, stress--[oxymorphone](#) (0.02-0.1 mg/kg IV)

CONTRAINDICATIONS

Antipyretic drugs (e.g., salicylates and [flunixin meglumine](#)) are contraindicated in animals with nonpyrogenous hyperthermia, because the temperature set point is normal and lowering it with antipyretics will not lessen hyperthermia.

PATIENT MONITORING

- Monitor temperature during cooling down, since [hypothermia](#) can develop rapidly.
- Blood pressure, central venous pressure, capillary refill time, and chest auscultation are valuable aids in detecting overhydration.
- Use a closed urine collection system to monitor urine output if renal failure is suspected.
- Monitor ECG for cardiac arrhythmias.
- Following the initial cool down, keep patient in a cool and well-ventilated room.
- Monitor PCV and total solids, and recheck serial blood gases, CBC, coagulation profile, serum biochemistry, and urinalysis daily to detect possible complications.



POSSIBLE COMPLICATIONS

- Failure of any major organ system
- [Coma](#), seizures, and respiratory arrest secondary to cerebral edema
- Acute renal failure
- Disseminated intravascular coagulation
- Pulmonary edema and [acute respiratory distress syndrome](#)
- Cardiac arrhythmias
- Rhabdomyolysis
- Hepatocellular necrosis

EXPECTED COURSE AND PROGNOSIS

- The prognosis is guarded to grave, depending on the presence or absence of an underlying disease condition and the development of complications. Mortality seems to be proportional to the duration and intensity of hyperthermia and the time required to achieve a normal body temperature.
- Recovering dogs may have residual neurologic deficits and nephrogenic [diabetes insipidus](#).

