

## CHAPTER 9

# Heat Injury

Heat loss in dogs is via convection, conduction, and evaporative loss, contrasted to radiant heat loss of humans.<sup>1</sup> Panting is the only significant cooling mechanism for dogs; they cannot sweat. While the reference range for normal MWD rectal temperature is 99-102.5°F, it is common for rectal temperatures to be > 106°F during exercise with no adverse effects.<sup>2,3</sup> However, each MWD's heat tolerance is different, and fatal heat stroke cases have been associated with rectal temperatures as low as 105.8°F.<sup>2,4,5</sup> A study<sup>3</sup> in exercising MWDs demonstrated that body core temperatures up to 106°F are not uncommon in healthy MWDs during work, and that core temperature continues to increase over the course of 15 minutes after exercise. Dogs not affected with heat injury rapidly normalized their temperatures within 15-20 minutes.

Heat-induced injury in MWDs usually develops secondary to heavy physical exertion in hot and humid environments. Rarely, MWDs may develop heat-induced injury if left in or trapped in closed vehicles or containers in a high-heat environment, or due to partial airway obstruction of any cause. The subsequent hyperthermia exceeds the capability of the MWD to compensate. Risk factors for MWD heat injury include inadequate acclimatization, a history of prior heat injury events, and obesity.<sup>5-8</sup>

There are three types of heat-induced injury in veterinary patients, based on the severity of the resulting injury: mild ("heat stress"), moderate ("heat exhaustion"), or severe ("heat stroke"). Severe heat injury in dogs is associated with a mortality rate of 50-64%.<sup>4,6,9,10</sup>

## Mild Heat Injury<sup>11-13,15</sup>

- Mild heat injury is characterized clinically by development of excessive thirst, discomfort associated with physical activity (e.g., seeking shade, reluctance to move, or both), but with controlled panting (i.e., the patient can control or reduce panting when exposed to a noxious inhalant such as alcohol).
- Treatment of mild heat injury involves removing the patient from the source of heat, stopping exercise, cooling by use of fans or movement to an air-conditioned area, and offering cold water for the dog to drink.
- Close monitoring for several hours is necessary to ensure heat stress does not progress or rebound hypothermia does not develop.
- Key parameters to monitor, in addition to frequent body temperature measurement, include changes in mentation, development of petechiae or ecchymoses, hematuria, weakness or collapse, clinical signs of shock (e.g., tachypnea, tachycardia, weak pulse quality, pale mucous membranes), and anxiety or restlessness.

## Moderate Heat Injury (Heat Exhaustion)<sup>2,11-14</sup>

- Moderate heat injury is present when the signs of heat stress are present, as well as weakness, anxiety, and uncontrolled panting (i.e., the patient cannot reduce or stop panting when exposed to a noxious inhalant), but CNS abnormalities are not present.
- Treatment of moderate heat injury is the same as for heat stress, but more aggressive cooling measures are often necessary.
- The patient must be removed from the source of heat and all activity must be stopped.
- Cooling by use of fans or movement to an air-conditioned area should be done if possible. The hallmark treatment for moderate and severe heat injuries is to thoroughly soak the hair coat to the skin with tepid water to reduce core body temperature.
- Close monitoring for several hours as stated for heat stress is necessary to ensure heat exhaustion does not progress or rebound hypothermia does not develop.

## Severe Heat Injury (Heat Stroke)<sup>4,6,9-14</sup>

- Severe heat injury is present when signs of heat exhaustion are present, coupled with varying degrees of central nervous system (CNS) abnormalities (encephalopathy). The most common CNS abnormalities include changes in mentation and level of consciousness (e.g., obtunded, stupor, coma), seizures, abnormal pupil size, cortical blindness, head tremors, and ataxia. Heat stroke is a life-threatening condition.
- It is characterized by a severe increase in core temperature and widespread, multiple organ injury with risk of progression to multi-organ failure.
- No specific body temperature defines heat stroke in MWDs; however, temperatures as low as 105.8°F have been associated with pathology. Most commonly, heat stroke is seen in MWDs with rectal temperatures >107°. Studies report multiple serious complications and high fatality rates in heat stroke patients despite proper treatment.<sup>3-5</sup> [Table 12](#) describes the management of MWDs with heat-induced injury.

## Initial Management Considerations for Heat-injured MWDs<sup>8,11,14</sup>

- Triage of the MWD with heat injury is similar for other types of injury or illness, but with emphasis on assessing mentation, airway and breathing, circulation, and body temperature. MWDs typically present with obtundation or stupor; however, heat stroke patients can be alert and responsive, stuporous, or comatose. MWDs presenting in stupor or coma are in imminent danger of death. Some heat stroke patients present actively seizing.
- The patient's initial physiological response to hyperthermia will be to move blood to the surface vessels to maximize conductive cooling. The initial phase will generally include renal and splanchnic vasoconstriction,

peripheral vasodilatation, splanchnic vasoconstriction, peripheral vasodilatation, and increased cardiac output. Over time, if the body temperature remains high, splanchnic and renal vasoconstriction will eventually fail, creating conditions favorable for venous pooling and hypovolemia or distributive shock. Monitor continuous ECG, blood pressure, mucus membrane color, and capillary refill time.

- Rectal temperature may lag behind core body temperature by up to 15 minutes. Heat stroke patients may therefore be hypothermic, hyperthermic, or normothermic upon presentation, based on cooling measures initiated by the handler and length of time since onset of heat stroke.

## Emergency Management of Heat Injury<sup>8,11,14,16</sup>

- Intubate MWDs if apneic or not breathing adequately; maintain IPPV at 8-12 breaths/minute. Protect the airway if intubated while cooling with water to reduce chances of aspiration of running water. Provide supplemental oxygen until normoxemia is confirmed with the MWD breathing room air. Use “blow by” technique if not intubated (See [Chapter 3](#)), as oxygen masks can increase humidity and prevent maximal heat dissipation.
- MWDs displaying any clinical signs of heat injury require emergency cooling measures. Use a combination of cooling methods! The rate of cooling should be as rapidly as possible until the body temperature is 103° F. The most rapid, practical, and effective method to reduce body temperature is to soak the patient thoroughly to the skin with room-temperature water. The patient can be placed under running tepid water in a well-drained tub or submerged partially in a tub of tepid water. The key is to soak the entire MWD as rapidly as possible, and to soak through the hair coat to soak the skin thoroughly.
- The value of intravenous fluids in patient cooling and support cannot be overstated. Unless there are specific contraindications, intravenous fluid therapy using room-temperature fluids should be initiated for any MWD with heat stroke. Adequate circulating blood and plasma volume are required for conduction to maximize heat dissipation, and IV room-temperature fluids reduces core body temperature.
- Use additional cooling methods! Direct fans on the MWD to facilitate evaporative and surface cooling. If possible, move MWD to a cool room or reduce the ambient temperature of the treatment room.
- Cold-water immersion may be considered for young and healthy animals, whilst evaporative cooling (spraying the skin and coat with water in combination with air movement) only should be performed in geriatric animals or those with comorbidities. Placing isopropyl alcohol on the footpads is commonly done, but is relatively ineffective because the paw pads have such a small surface area.
- Once the MWD’s body temperature is <103°, provide passive warming support, cease all cooling efforts (e.g., remove fans, return room temperature to normal), and dry the MWD’s skin. Monitor rectal temperature continuously, and be prepared to actively warm the patient to prevent an excessive drop in body temperature (rebound hypothermia). HCPs should anticipate a period of rebound hypothermia, and understand that the delay between rectal temperature and true core temperature likely means that the true core temperature may be lower. Active rewarming should be initiated if the rectal temperature falls below 100° F.
- HCPs should evacuate any MWD heat stroke casualty to veterinary facilities on an URGENT basis if feasible

# Monitor and Treat Concurrent or Developing Problems<sup>6,14,17</sup>

- Shock is common in MWDs with heat stroke. Manage shock (See Chapter 6, [Figure 33](#)). Monitor blood pressure, lactate clearance, clinical assessment of perfusion, and assessment of volume status until the MWD is evacuated.
- Glucose, acid-base, and electrolyte abnormalities are common. If able, monitor blood glucose and venous blood gas analyses every 6-12 hours. Monitor arterial blood gas analysis (or surrogates such as pulse oximetry and capnography). Dextrose should be administered to hypoglycemic dogs as a single slow bolus (1 mL/kg of 50% dextrose diluted at least 1:2 in a sterile fluid) followed by a 2.5–5% dextrose CRI, with close monitoring to maintain normoglycemia. Supplement maintenance IV fluids with KCl at 20 mEq/L to maintain normokalemia.
- Hypercoagulable and consumptive coagulopathic states (e.g., thrombocytopenia, DIC) are common.<sup>8,17</sup> Gastrointestinal hemorrhage is common during recovery, and may be present on admission. Canine fresh frozen plasma (20 ml/kg), freeze dried plasma, or canine serum albumin may be necessary; however, these may not be available to HCPs. HCPs must NOT give human FFP, human serum albumin, or human blood to dogs. See the Transfusion for the Military Working Dog CPG for further guidance.<sup>18</sup> Coagulation testing for MWDs will be problematic for HCPs, as analyzers for human blood will not provide accurate results for canine blood. HCPs should monitor the MWD and CBCs (if available) for evidence of thrombocytopenia (petechiae, ecchymoses, low platelet count). HCPs should monitor for signs of clotting abnormalities (e.g., hematoma formation, intracavitary bleeding, epistaxis, hematuria). URGENT evacuation to veterinary facilities is critical to survival of MWDs that develop bleeding disorders, as veterinary personnel can facilitate canine blood product collection and administration.
- Cardiac arrhythmias, especially ventricular arrhythmias, are common. Perform continuous or intermittent ECG monitoring. Treat ventricular arrhythmias only if causing hemodynamic compromise, using lidocaine (2 mg/kg IV bolus, then 50-75 mcg/kg/min CRI).
- Vomiting and diarrhea are typical. Diarrhea is often hemorrhagic. Start prophylactic systemic antibiotic therapy (See [Chapter 14](#)) for any MWD with hemorrhagic diarrhea. Start famotidine therapy (1 mg/kg IV, IM, or PO q12h) for any MWD with heat stroke. Treat nausea and vomiting with ondansetron (1 mg/kg, IV or PO, q12-24h). Add sucralfate (1 gram PO q8h) for any MWD with hematemesis. Allow food and water once vomiting has resolved. Hygiene is critical, and bedding should be changed as needed; shave long tail hair and wrap tails to minimize soiling.
- Acute kidney injury resulting in renal insufficiency is possible. Maintain urine production at 1-2 ml/kg/hour and monitor for pigmenturia. Monitor for subcutaneous edema, body weight gain, and nasal discharge as evidence of fluid overload.<sup>19</sup> Monitoring urine output in males will be difficult without canine-specific urethral catheters; use estimates of voiding or weigh absorbent pads or blankets to estimate urine output. Alternatively, in male dogs, adapt a 10- or 12-Fr suction catheter (ubiquitous in trauma bays) by removing the control valve end, aseptically inserting the remaining catheter into the urethra to the level of the urinary bladder, and connecting the distal end to a sterile empty IV bag or closed collection system by way of an adapter.

- Treat seizures with a benzodiazepine (diazepam 0.3 mg/kg; IV, IN, rectally or midazolam, 0.3 mg/kg; IV, IM or IN) as needed, up to 3 doses over 2 hours or as a 0.25 – 0.4 mg/kg/hour IV CRI for recurrent seizures. If seizures continue, give phenobarbital (15-20 mg/kg total dose, divided into 4 doses and given IV every 30-60 minutes as needed to control seizures) and start oral phenobarbital (2.5 mg/kg PO q12h) 12 hours after last IV dose. Treat any MWD with stupor or coma with mannitol on admission (0.5-1 grams/kg, IV, over 20 minutes) and repeat every 4-6 hours for up to 2 additional doses). Rule out hypoglycemia. CNS abnormalities typically resolve with mild or moderate cases of heat stroke. Cortical blindness is common and usually resolves over a period of several days.

Initiate veterinary telemedicine consultation using the ADVISOR line (1-833-238-7756 or DSN 312-429-9089) and referral to a veterinary facility for continued care as soon as possible.

## Prognosis: Nucleated Red Blood Cells, Heat Injury Severity Scoring System

- Risk factors for death from heat stroke include obesity, prolonged time-lag from heat injury to initiation of appropriate treatment, abnormal mental status, hypoglycemia, and azotemia.<sup>6,8</sup>
- A study<sup>20</sup> in 40 dogs demonstrated that 90% of dogs presenting with heatstroke had increased peripheral nucleated red blood cells (nRBC) at presentation, with a cut-off point of 18 nRBC/100 leukocytes corresponding to a sensitivity and specificity of 91 and 88%, respectively, for death. Dogs with nRBC above this cut-off were significantly more likely to have life-threatening complications such as renal failure and DIC. Thus, rapidly screening for the presence of nRBC may be useful to confirm clinical suspicion of heatstroke, and guide aggressiveness of therapy and monitoring.
- A severity scoring system has been validated in dogs with clinical heat stroke that may prove useful to gauge severity of injury and prognosis based on key clinical and laboratory parameters noted within the first 24 hours of admission. Parameters useful to measure include heart rate, blood glucose, and coagulation tests.

**TABLE 12. MWD HEAT INJURY PROTOCOL<sup>5-10</sup>**

PHASE	CLINICAL SIGNS	
<b>MILD</b> (Stress)	<u>Controlled</u> panting, excessive thirst, discomfort	Dehydration typically accompanies heat injury --> treat dehydration and monitor for shock
<b>MODERATE</b> (Exhaustion)	<u>Uncontrolled panting</u> , weakness, ataxia, anxiety, petechiae/ecchymoses	
<b>SEVERE</b> (Stroke)	Moderate signs, <b>PLUS</b> <u>CNS signs</u> , collapse, shock	
<b>TREATMENT OF MILD HEAT INJURY</b>		
<div>1. Cease work and remove MWD's gear or vests.</div> <div>2. Remove from source of heat (move to shade or air-conditioned area. Use fans if available)</div> <div>3. Offer cool water in small increments frequently</div> <div>4. Monitor temperature q 15-30 min to ensure mild injury doesn't progress; perform serial physical exams</div>		
<b>TREATMENT OF MODERATE AND SEVERE HEAT INJURY -- ANY DOG WITH TEMPERATURE &gt;105° F</b>		
<div>1. Immediately soak the dog's skin with room-temperature water – Remove gear or vests and saturate to the skin!! Use fans if available.</div> <div>2. Continue soaking until body temperature is reduced to &lt;105° F.</div> <div>3. Start IV fluid therapy</div> <div>4. Follow SHOCK RESUSCITATION PROTOCOL if dog is in shock (See <a href="#">Chapter 6, Figure 33</a>)</div> <div>5. Give IV crystalloid fluids at 3-5 mL/kg/hr if not in shock</div> <div>6. Triage the patient based on severity of injury</div> <div>7. Protect the airway (intubate or tracheostomy <i>prn</i>), treat dehydration or shock, support ventilation <i>prn</i></div> <div>8. Be prepared to support/correct REBOUND HYPOTHERMIA</div> <div>9. Dog may be hypothermic on arrival or develop hypothermia during treatment</div> <div>10. DO NOT USE cold or iced IV fluids, surface cooling with ice, or ice water immersion</div>		
CEASE cooling efforts once the body temperature is <103° F to prevent rebound hypothermia. Actively warm the dog if temperature is <100° F		
<b>PROVIDE INTENSIVE MONITORING AND MANAGEMENT</b>		
Maintain NORMOTENSION -- Target MAP of >65 mmHg or Systolic BP >90 mmHg		
Maintain VENTILATION -- Target RR of 8 - 10 bpm -- Target E <sub>T</sub> CO <sub>2</sub> 35-45 mmHg		
Maintain OXYGENATION -- Target SpO <sub>2</sub> >95% with supplemental oxygen		
<b>CONTROL SEIZURES</b>		
MIDAZOLAM or DIAZEPAM	0.3 mg/kg -- IV, IO, or INTRANASAL <i>prn</i>	
<b>MANAGE CEREBRAL EDEMA</b>		
MANNITOL	0.5-1 grams/kg -- IV over 20 min	
<i>or</i>		
HYPERTONIC SALINE (if mannitol not available)	4 mL/kg IV bolus over 15 minutes	

**TABLE 12: MWD HEAT INJURY PROTOCOL<sup>8,1-15,21</sup> (continued)****CONTROL PATHOLOGIC VENTRICULAR ARRHYTHMIAS****LIDOCAINE**2 mg/kg IV bolus, then CRI @  
50 - 75 mcg/kg/min**CORRECT H's and T's FIRST****CONTROL HYPOGLYCEMIA**

- SUPPLEMENT IV fluids with 5% dextrose
- MONITOR blood glucose q4-6h
- AVOID intensive glucose titration

**MANAGE ANCILLARY PROBLEMS**

- Anti-emetics + gastrointestinal protectants
- Potassium Supplementation
- Mobility

## Heat Injury References

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