

JOINT TRAUMA SYSTEM K9 CLINICAL PRACTICE GUIDELINE



Heat Injury (K9CPG:09)

This CPG provides guidance on recognition, treatment and monitoring of heat injury in military working dogs.

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SUMMARY OF CHANGES

1. Removed description of physiologic response to heat injury and added clarification of emergency cooling measures and proper water temperatures for soaking the Military Working Dog (MWD).
2. Added parameters for treatment and monitoring of hypoglycemia and guidelines for potassium supplementation.
3. Defined parameters for treatment of ventricular arrhythmias.
4. Updated medication guidelines for supportive care of MWDs with vomiting and diarrhea and for treatment of seizures.
5. Removed nucleated red blood cells and heat injury severity scoring system prognostic indicators.
6. Updated MWD heat injury protocol summary table.

BACKGROUND

Heat loss in dogs is primarily via convection, conduction, and evaporative loss, contrasted to radiant heat loss of humans.¹ Panting is the only significant cooling mechanism for dogs; they do not have widespread sweat glands. Normal MWD rectal temperatures are 99-102.5°F (37.2-39.2°C), and it is common for rectal temperatures to be > 106°F (41.1°C) during exercise with no adverse effects.^{2,3} 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 (41°C).^{3,4,5} A study in exercising MWDs demonstrated that body core temperatures up to 106°F (41.1°C) are common in healthy MWDs during work, and that core temperature continues to increase over the course of 15 minutes after exercise.³ During recovery, 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. MWDs may also develop heat-induced injury if left in or trapped in closed vehicles or containers or due to partial airway obstruction of any cause. Risk factors for MWD heat injury include inadequate acclimatization to high-intensity activity and climatic conditions, inadequate hydration, a history of prior heat injury events, and obesity.⁵⁻⁸

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%.^{4,6,9,10} Heat injury in dogs can progress very quickly. Rapid treatment as soon as the first clinical signs are noted is imperative.

MILD HEAT INJURY (HEAT STRESS)^{11-13,15}

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 MWD can control or reduce panting when exposed to a noxious inhalant such as alcohol or when presented their toy reward).

Treatment of mild heat injury (see [Table 1](#)) 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 cool water for the dog to drink.

Close monitoring for several hours is necessary to ensure heat stress does not progress.

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)^{2,11-14,16-18}

Moderate heat injury is present when the signs of heat stress are present, as well as weakness, distress, and uncontrolled panting (i.e. the patient cannot reduce or stop panting when exposed to a noxious inhalant), but central nervous system (CNS) abnormalities, such as change in mentation, are not present.

Treatment of moderate heat injury is the same as for heat stress, but more aggressive cooling measures are often necessary. (See [Table 1](#).)

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. For moderate and severe heat injuries, thoroughly and continuously soak the hair coat with tepid water (60 to 86°F or 15.6 to 30°C) to reduce core body temperature.^{16,17,18}

Intravenous fluid therapy should be initiated. (See [Table 1](#).)

Close monitoring for several hours ensures heat exhaustion does not progress or rebound hypothermia does not develop.

SEVERE HEAT INJURY (HEAT STROKE) ^{4,6,9-14}

Severe heat injury is present when signs of heat exhaustion are present, coupled with varying degrees of 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 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 (41°C) have been associated with pathology. Most commonly, heat stroke is seen in MWDs with rectal temperatures >107°F (41.7°C). Studies report multiple serious complications and high fatality rates in heat stroke patients despite proper treatment.³⁻⁵ [Table 1](#) describes the management of MWDs with heat-induced injury.

TRIAGE & INITIAL MANAGEMENT CONSIDERATIONS ^{8,11,14}

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. For MWDs with severe heat injury, they may present with obtundation or stupor; however, heat stroke patients can still be alert and responsive. MWDs presenting in stupor or coma are in imminent danger of death. Some heat stroke patients present actively seizing.

Rectal temperature may lag behind core body temperature by up to 15 minutes. Continually monitor temperatures even if normal at presentation.

EMERGENCY MANAGEMENT OF HEAT INJURY ^{8,11,14,16}

MWDs displaying any clinical signs of heat injury require emergency cooling measures. The rate of cooling should be as rapid as possible until the body temperature is 103-103.5°F (39.4-39.7°C). The most rapid, practical, and effective method to reduce body temperature is to soak the patient thoroughly to the skin under running tepid water (60-86°F or 15.6-30°C) or submerge partially in a tub of tepid water.¹⁶⁻¹⁸ The key is to soak the entire MWD as rapidly as possible, and to soak through the hair coat to soak the skin thoroughly. 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.

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 reduce core body temperature.

Intubate MWDs if apneic or not breathing adequately; maintain intermittent positive pressure ventilation (IPPV) at 8-12 breaths/minute. When intubated, make sure the cuff is properly inflated to protect the airway. Provide supplemental oxygen until pulse oximetry of >95% is confirmed with the MWD breathing room air. Use “blow by” technique to deliver oxygen if not intubated (see [K9 Emergency Airway Management CPG](#)), as oxygen masks can increase humidity and prevent heat dissipation.

Placing isopropyl alcohol on the footpads is commonly done and may have some effectiveness.¹⁷

Once the MWD’s body temperature is 103-103.5°F (39.4-39.7°C), cease all cooling efforts (e.g., remove fans, return room temperature to normal). Then, dry the MWD and provide passive warming support (such as covering with a blanket), if necessary. Monitor rectal temperature continuously and be prepared to actively warm the patient to prevent an excessive drop in body temperature (rebound hypothermia). Providers 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 (such as forced air warming) should be initiated if the rectal temperature falls below 100°F (37.7°C).

Providers should evacuate any MWD heat stroke casualty to veterinary facilities on an URGENT basis if feasible.

MONITORING & TREATMENT OF CONCURRENT OR DEVELOPING PROBLEMS^{6,14,19-23}

Shock is common in MWDs with heat stroke and should be managed as indicated (see [K9 Shock Management CPG](#)). 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. Dextrose should be administered to hypoglycemic dogs (blood glucose < 60 mg/dL) as a single slow bolus (1 mL/kg IV of 50% dextrose diluted 1:2-1:4 in a sterile fluid). If hypoglycemia persists, administer a 2.5–5% dextrose CRI, with close monitoring to maintain glucose between 60-150 mg/dL.²⁰ Monitor arterial blood gas analysis (or surrogates such as pulse oximetry and capnography). If hypokalemia develops (< 3.5 mEq/L), supplement IV fluids with KCl as indicated in [Table 2](#) to maintain normokalemia.²¹ Do not bolus IV fluids that contain added potassium!

Hypercoagulable and consumptive coagulopathic states (e.g., thrombocytopenia, disseminated intravascular coagulopathy) are common.^{8,19} 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 providers. Providers must NOT give human fresh frozen plasma or human blood to dogs and should only administer human serum albumin in rare cases to select patients with guidance from a veterinary clinical specialist (AOC 64F Veterinary Clinical Medicine Officer). See the [Transfusion for the Military Working Dog CPG](#) for further guidance.²² Coagulation testing for MWDs may not be readily available and is not reliable on analyzers used for human blood. Providers should monitor the MWD and CBCs (if available) for evidence of thrombocytopenia (petechiae, ecchymoses, low platelet count) or 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 ventricular tachycardia is sustained (> 160 bpm for 30 seconds or longer) or if the ventricular arrhythmia is causing hemodynamic compromise (hypotension or other evidence of poor perfusion), using lidocaine (2 mg/kg IV bolus, then 50-75 mcg/kg/min CRI).

Vomiting and diarrhea are typical. Diarrhea is often hemorrhagic. Start pantoprazole therapy (1 mg/kg IV q12h) for any MWD with heat stroke. Treat nausea and vomiting with ondansetron (1 mg/kg, IV q12h) and, if available, maropitant citrate (1 mg/kg IV or SQ q24h). Add sucralfate (1 gram PO q8h) for any MWD with a history of hematemesis, after vomiting has stopped. Allow food and water once vomiting has resolved. Hygiene is critical, and bedding should be changed as needed; shave long tail hair 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 (weigh every 6 to 12 hours), and nasal discharge as evidence of fluid overload.²³ Monitoring urine output in males will be difficult without canine-specific urethral catheters and urinary catheter placement in female dogs is difficult. 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. If available, monitor renal values through blood chemistry every 24 hours.

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 levetiracetam at a 60 mg/kg IV loading dose once, followed by 20 mg/kg IV every 8 hours. 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). Alternatively, hypertonic saline can be administered (4 mL/kg bolus over 15 minutes). 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 consultation to the overseeing veterinary clinical specialist (AOC 64F) as soon as possible and coordinate referral to a higher level of care as soon as possible. If a 64F cannot be reached, can contact the ADVISOR line at 1-833-238-7756 or DSN 312-429-9089 to reach additional veterinary subject matter experts.

Table 1. MWD Heat Injury Protocol^{1-18,24}

MWD HEAT INJURY PROTOCOL		
PHASE	CLINICAL SIGNS	
MILD (Stress)	<u>Controlled</u> panting, excessive thirst, discomfort.	Dehydration typically results from heat injury → treat dehydration and monitor for shock
MODERATE (Exhaustion)	<u>Uncontrolled</u> panting, weakness, ataxia, anxiety, petechiae/ecchymoses.	
SEVERE (Stroke)	Moderate signs <u>plus</u> CNS signs, collapse, shock.	
TREATMENT OF MILD HEAT INJURY		
<ol style="list-style-type: none"> Cease work and remove MWD's gear or vests. Remove from source of heat. Move to shade or air-conditioned area. Use fans if available. Offer cool water in small increments frequently. Monitor temperature every 15-30 minutes to ensure mild injury doesn't progress; perform serial physical exams. 		
TREATMENT OF MODERATE AND SEVERE HEAT INJURY		
<ol style="list-style-type: none"> Perform primary survey and assess airway, breathing and circulatory system. Immediately initiate active cooling measures. Soak the dog's hair and skin with tepid water – remove gear or vests. Use fans if available. Continue active cooling measures until body temperature is reduced to 103 – 103.5°F. Obtain vascular access and begin IV fluid therapy with an initial crystalloid bolus of 10-20 mL/kg. Assess for shock. If present, follow the shock resuscitation protocol (Shock Management K9 CPG). Give IV crystalloid fluids at 3-5 mL/kg/hour if not in shock. Be prepared to support/correct rebound hypothermia (dog may be hypothermic on arrival or develop hypothermia during treatment). Monitor for any development of additional complications that may require treatment such as CNS abnormalities, cardiac arrhythmias, bleeding disorders, or electrolyte abnormalities. <p style="color: red;">CEASE cooling efforts once the body temperature is 103 – 103.5°F to prevent rebound hypothermia. Actively warm the dog if the temperature is < 100°F.</p>		
PROVIDE INTENSIVE MONITORING AND MANAGEMENT		
Maintain <u>normotension</u> – target MAP of >65 mmHg or systolic BP >90 mmHg Maintain <u>ventilation</u> – target RR of 8 – 10 bpm and ETCO ₂ of 35 – 45 mmHg Maintain <u>oxygenation</u> – target SpO ₂ >95% with supplemental oxygen		
CONTROL SEIZURES		
Midazolam or Diazepam	0.3 mg/kg – IV, IO, or intranasal PRN <i>Midazolam can also be administered IM.</i> <i>Diazepam can also be administered per rectum.</i>	
MANAGE CEREBRAL EDEMA		
Mannitol OR Hypertonic saline	0.5 – 1 grams/kg – IV over 20 minutes ----- 4 mL/kg IV bolus over 15 minutes	
CONTROL PATHOLOGIC VENTRICULAR ARRHYTHMIAS		
Lidocaine 2 mg/kg IV bolus, then: 50 – 75 mcg/kg/min CRI	Correct H's and T's first: <ul style="list-style-type: none"> Hypovolemia, hypoxia, hydrogen ion (acidosis), hypoglycemia, hyper/hypokalemia, hypothermia Tension pneumothorax, tamponade (cardiac), toxins, thrombosis 	
CONTROL HYPOGLYCEMIA	MANAGE ANCILLARY PROBLEMS	
<ol style="list-style-type: none"> Supplement IV fluids to 2.5 – 5% final dextrose concentration. Monitor blood glucose every 4-6 hours. 	<ol style="list-style-type: none"> Antiemetics + gastrointestinal protectants. Potassium supplementation. Mobility 	

Table 2. Guideline for Potassium Supplementation ²¹

Serum Potassium Concentration (mEq/L)	mEq KCl to Add to 1 L of Maintenance Fluids
< 2.0	80
2.1 – 2.5	60
2.6 – 3.0	40
3.1 – 3.5	25 - 30
3.6 – 5.0	20
> 5.0	None

PERFORMANCE IMPROVEMENT (PI) MONITORING

POPULATION OF INTEREST

All MWDs with diagnosis of heat injury.

INTENT (EXPECTED OUTCOMES)

- Recovery from heat injury.
- No evidence of organ injury (sustained CNS abnormalities, kidney or other organ compromise).
- Proper documentation of heat injury event in MWDs medical record.

PERFORMANCE / ADHERENCE MEASURES

- Number and percentage of patients in the population of interest (deployed MWDs) that sustained heat injury.
- Specify whether mild, moderate or severe, if possible.
- Number and percentage of patients in the population of interest (deployed MWDs) that recovered from heat injury event.
- Number and percentage of MWDs that returned to duty versus those that were medically retired following the heat injury event.

DATA SOURCE

- Patient Record
- Department of Defense MWD Trauma Registry

SYSTEM REPORTING & FREQUENCY

The above constitutes the minimum criteria for PI monitoring of this K9 CPG. System reporting will be performed annually; additional PI monitoring and system reporting may be performed as needed.

The system review and data analysis will be performed by direction of the K9C4 Chair.

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