Canine Tactical Field Care Part Two – Massive Hemorrhage Control and Physiologic Stabilization of the Volume Depleted, Shock-Affected, or Heatstroke-Affected Canine

Wesley M. Taylor, D.V.M., Diplomate, ACLAM

ABSTRACT

Military and law enforcement agencies have seen a dramatic increase in the utilization of military working dogs (MWDs) and working canine officers, respectively both at home and in foreign deployments. Due to the fact that professional veterinary care is often distant from internal disaster or foreign deployment sites, the military medic, police tactical medic, or other first-response medical care providers may be charged with providing emergency or even basic, non-emergency veterinary care to working canines. The medical principles involved in treating canines are essentially the same as those for treating humans; however, the human healthcare provider needs basic information on canine anatomy and physiology, and common emergency conditions, in order to provide good basic veterinary care until a higher level of veterinary care can be obtained. This article represents the second in a series designed to provide condensed, basic veterinary information on the medical care of working canines, including police canines, federal agency employed working canines, and search-and-rescue dogs, in addition to the MWD, to those who are normally charged with tactical or first responder medical care of human patients. This article focuses on diagnosing and treating some of the more common high-mortality conditions affecting canines in the field including massive hemorrhage, volume-depletion, shock, and heatstroke.

The recent upsurge in the use of working canines as a result of the Global War on Terror has resulted in a need for more veterinary healthcare providers in the field setting.[1-6] The military working dog (MWD) is a critical member of the tactical team or the search and rescue team and as such it is susceptible to similar injuries and conditions as its human colleagues. Whether deployed overseas in support of military missions or at home in support of terrorism events or natural disasters, these canines are becoming casualties at a rate that exceeds the existing veterinary care system capabilities, especially in these deployed situations where it is simply not feasible to have a veterinarian on site with each canine team. Professional veterinary care may be hours to days away from the location of the injured MWD, and providing veterinary care frequently falls to the dog handler, combat medic, or other human healthcare provider.[4,6-8] For this reason, it is critical that non-veterinary healthcare providers be trained in basic veterinary medical skills so that working canines can be returned to work expeditiously.

Analysis of the types of injuries and illnesses experienced by MWDs in deployed situations provides us with a list of common injuries and illnesses experienced by these dogs. Conditions of importance include pad injuries, gunshot wounds, orthopedic injuries, lacerations, common infections, diarrhea and vomiting, volume depletion, massive hemorrhage, shock, and heatstroke.[4,6-8] Some of these conditions are high morbidity and low mortality conditions that are amenable to treatment in the field. Others are high mortality conditions with little chance of treatment success in the field.

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Finally, some conditions represent potentially high mortality conditions with the potential of being treated successfully in the field. Of these, volume-depletion, massive hemorrhage, shock, and heatstroke are potentially fatal conditions, yet these conditions lend themselves to the diagnostic and treatment capabilities of those personnel already familiar with field medicine in the human casualty treatment milieu.

These potentially fatal conditions present with cardiovascular abnormalities, and it is essential, that the care provider be able to discriminate one condition from the other by physical exam and basic physiologic signs. For these reasons, this article will focus on differentiating these conditions diagnostically, with the objective of teaching the dog handler or human healthcare provider, to accurately diagnose and treat these conditions with sufficient skill to enable the canine casualty to survive to the next higher level of veterinary care.

VOLUME DEPLETION / DEHYDRATION

One of the most common conditions experienced by working canines in the field is volume depletion or dehydration.[9,10] Even during operations in temperate climates, working canines require a significant amount of water in order to maintain physiologically normal hydration. The author has received reports from military veterinarians and canine handlers that dogs working long hours in arid zones can require up to 15L per day in oral rehydration.[8] (Table 1) In any case, adequate hydration is paramount to maintaining normal physiological function, especially during and after severe exertion.

Dehydration can be detected clinically in dogs and can be estimated within the range of 8-15% of body weight.[11] This means that an 85lb (38.6kg) working dog can lose up to 3L of fluids before the resultant dehydration is clinically detectable. This is an important fact for canine handlers and caregivers to remember, as dogs with limited access to fresh water are at high risk of dehydration. In fact, a study of dogs deployed to the World Trade Center and the Pentagon in Search and Rescue (SAR) missions in September 2001 found that dehydration was the third most common problem found in SAR dogs behind minor trauma and weight loss.[7]

Clinical signs of dehydration in the 8-10% range include elevated heart rate of between 90 to 120 bpm at rest, increased skin tent time (decreased skin turgor), and dry mucous membranes. As dehydration worsens to above 10% of body weight, additional clinical signs become evident including "doughy" abdominal palpation, sunken eyes, extended capillary refill time (CRT), possibly "thready" or weak pulses, and in a very severely dehydrated animal, a decrease in metal status may be noted.[11]

It is critical that the canine handler and healthcare team ensure that working canines remain adequately hydrated. Since a dog may need to consume many liters per day of water in extreme environments and under heavy work loads, it can be difficult to impossible for the individual handler to carry sufficient fluids on his person. For this reason, teams must ensure that canine units have access to stores of water during the workday; or that teams be additionally provisioned with individual water purification devices for use in the field.

Table 1: Canine Field Care Card					
Parameter	At Rest	Exercise	Drug	Standard Dose	CV Shock Dose
Temperature	100.5-101.5	101.0-104	Crystalloids	2.0-3L/24hr	10-50 ml/kg/hr *
Heart rate	60-75	75-130	6% hetastarch	n/a	5ml/kg bolus up to 20mg/kg total*
Respiratory rate	10-20	30-panting	Morphine	0.5–2mg/kg IM	n/a
Mucous membranes	Pink	Bright pink	Diphenhydramine	1mg/lb q 6-8 hrs	n/a
Capillary refill time	1-2 secs	1 sec	Diazepam	0.1-0.15mg/lb slow IV	Seizures: 0.5mg/lb IV bolus to effect
Pulses	Moderate	Bounding	Fentanyl	1-5mcg/kg/hr IV	n/a
Heart sounds	Behind left shoulder	Sinus arrhythmia except after exercise	Water	Maintenance 2.0-3L/24hr	Exercise 5-15L/24hr
Respiratory sounds	Caudal ½ of thorax	Louder than human	Food	Maintenance 4-6 cups dry / 24hr	Exercise 8-12 cups / 24hr

This table contains normal physiological parameters and physical exam findings for working canines in the weight range of 85 to 110 lbs. The drug doses denoted with an asterisk are from the "Shock" article in the textbook "The 5-Minute Veterinary Consult."[12] Other values are condensed and edited from articles referenced herein and are consistent with those used by this author in private practice on working canines.[4,8-15] This card may be photocopied and laminated for the use of individual JSOM subscribers.

Oral rehydration solutions that contain electrolytes are not recommended for the working canine. As opposed to people, dogs do not have sweat glands on the majority of their skin and most canine body fluid loss is via evaporation from the mouth and airway during panting. This water loss tends to be primarily water, as opposed to the water/electrolyte mix that is lost in humans during sweating.[9,10] For this reason, fluid supplements that are electrolyte rich can cause electrolyte disturbances in dogs, and thus water is the recommended oral rehydration solution for the working canine .

In the event that a working canine is diagnosed with clinically significant dehydration, which means if the dehydration is clinically detectable at all, the canine should be treated by performing intravenous catheterization and providing the dog with replacement fluids in the form of balanced-electrolyte crystalloids, such as Normosol®-R or lactated Ringer's solution. Initial crystalloid fluid replacement for hypovolemia can be given at a rate of up to 10 to 20ml/kg/hr.[11,12]

The required replacement volume can be estimated by multiplying the estimated percent of dehydration by the body weight in kg utilizing the following equation:

IV fluid replacement volume in L = % dehydration x body weight in kg

For example: For an 85 lb dog that is 8% dehydrated

0.08 (percentage dehydrated) x 38.6 (wt in kg) = 3.09L

This 85 lb dog would need 3.09L of replacement fluids given IV over the initial treatment phase (1-2 hrs).

Subcutaneous fluid supplementation is an option as an adjunctive fluid replacement method for mild dehydration. Subcutaneous fluid replacement in dogs is achieved by injecting crystalloid solutions below the skin in the interscapular space on the back. However, only a limited amount of fluid can be delivered in this fashion, perhaps up to one to two liters in a large dog, and the fluids are absorbed slowly from the subcutaneous space. As can be seen from the above calculation, a large dog will need at least three liters of fluids replaced quickly in the event of detectable dehydration, and this is simply too large a volume to be addressed by subcutaneous fluid replacement alone. However, in cases where intravenous access is impractical or impossible, subcutaneous fluid replacement is a viable means of initial treatment for dehydration.[9]

After the dehydration status has been assessed and corrected, it is important for the care provider to remember that ongoing maintenance fluid needs are 50ml/kg/day even in the resting patient at ambient temperatures. So, the 85lb dog in the example above would continue to require 1.93L per day in fluid therapy while in the treatment facility, which must be delivered either orally, subcutaneously, or intravenously.

SHOCK

Cardiovascular shock is the condition in which blood circulation is shunted away from extremities and large muscles and into the large vessels in the core of the body. It has also been described as failure of the microcirculation and is characterized by reduced tissue perfusion, impaired oxygen delivery, and inadequate cellular energy production.[4,13] Clinical signs of shock include an elevated heart rate, normal to dry but pale mucous membranes, a slow CRT, initially bounding (compensated shock) then rapidly weakening pulses (decompensated shock), and abnormal mentation.[4,12,13] Signs of dehydration may or may not be present, depending upon the hydration status of the patient just prior to entering the shock state.

The most important distinguishing factors in differentiating shock from dehydration is the extended CRT (>2 secs), the weakening pulses, and abnormal and declining mentation. It is important to note that heatstroke patients will have some component of cardiovascular shock, thus in differentiating these two conditions the practitioner must rely upon body temperature and condition of the mucous membranes.[4,12,13] The pale mucous membranes and dry

Table 2: Diagnostic Table for Dehydration, Shock, Hemorrhage, and Heatstroke.

Clinical Sign	Dehydration	Shock	Hemorrhage	Heatstroke
Temperature	Normal (101-105)	101-105	101-105	>106 at rest
Pulse rate	90-120	>120	>70	>120
Pulse rate change	Decreases with rest and rehydration	Increasing rate	Increasing rapidly	Increasing
Pulse quality	Normal	Bounding or weak	Normal then weakening	Weak
Mucous membrane color	Pink	Pale to white	Pink then worsening	Brick red
Mucous membrane moisture	Dry / tacky	Normal or dry	Normal or dry	Hypersalivation
Capillary refill time	Normal (1.0-1.5 secs)	Extended (>2 secs)	Normal then extended	Normal to extended
Respiratory rate	Panting – decreasing with rest and rehydration	Normal to panting	Normal to panting	Panting / unable to stop
Skin turgor	Extended (increasing time with increasing dehydration)	Normal or extended	Normal	Normal
Abdomen	Doughy / sunken Eyes sunken	Normal	Normal (distending in internal hemorrhage)	Full to tight (diarrhea and hematochezia common)

This table can be used as a working reference by the canine healthcare provider to attempt to differentiate the various conditions discussed herein one from another based upon a basic clinical assessment of the canine patient's temperature, pulse rate, pulse quality, mucous membrane color, capillary refill time, respiratory rate, skin turgor, and abdominal palpatation.

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mouth of the shock patient contrast dramatically with the bright red mucous membranes and hypersalivation of the heatstroke patient (Table 2).

Treatment of shock should be aimed at restoring normal circulating volume and hemodynamics by treating with intravenous colloids and other volume expanders such as hetastarch, mannitol, or a hemoglobin based oxygen carrier (HBOC) (see below under hemorrhage), combined with careful crystalloid supplementation. Pharmacologic intervention should include the use of "shock" doses of IV corticosteroids and pressor agents.[4,8,12,13]

In the treatment of decompensated shock, crystalloid fluids should be supplemented at a rate of between 10ml/kg/hr and 50ml/kg/hr.[4,12,13] Colloidal expanders such as 6% hetastarch should be given in boluses of 5ml/kg, up to a total dose of 20ml/kg until cardiovascular stability is reached.[4,12,13]

The use of corticosteroids in treating shock is controversial.[13] However, corticosteroids are still considered part of the standard veterinary armamentarium in treating shock. The primary drugs used in treating shock in dogs are methylprednisolone 10-30mg/kg and dexamethasone 4-6mg/kg.[4,8,12,13]

Other supplemental shock treatments include pressor agents to support blood pressure and circulatory function including dopamine 1-10mcg/kg/min IV and dobutamine 5-15mcg/kg/min IV.[12,13] In the absence of blood gas and electrolyte laboratory capabilities, supplementation of potassium (beyond standard electrolyte fluids) and bicarbonate should be avoided, as overdose of either of these compounds can be physiologically destabilizing or fatal.

HEATSTROKE

As mentioned previously, heatstroke in the canine patient was covered in depth in this journal very recently.[4] In an attempt to maintain the integrity of addressing heatstroke in the context of these other diagnostically similar conditions that are amenable to field treatment, it will be discussed again here.

Important predisposing factors to heatstroke in working canines include dehydration, lack of acclimation to a very hot and/or very humid region, previous episodes of heatstroke, long work shifts without adequate time for rest and cooling, long-haired breeds, and the potential for exposure to chemicals such as organophosphates or strychnine in the deployment area.[9,10] It should be noted that these chemicals may be common in some agricultural areas.

The most important clinical sign in differentiating heatstroke from simple dehydration, shock, and internal hemorrhage is the rectal temperature. It is not unusual for dogs in heatstroke to present with a rectal temperature in excess of 108 degrees Fahrenheit (F) and the rectal temperature is often higher than the detection range of a digital thermometer.[4,9,10,14] In many cases, the care provider will attempt to take the rectal temperature of a heatstroke dog only to find the thermometer and any other nearby instruments covered in bloody diarrhea.

The thermally regulating canine will have an elevated body temperature (up to 104-108 degrees F depending upon the breed and reference publication – see Table 1) for a brief period of time immediately after exercise, referred to as exertional hyperthermia; but this patient's temperature will move toward normal after 5 to 15 minutes of rest and panting.[4,9,10] The heatstroke patient's body temperature will not lower in response to rest and panting.

Panting and hypersalivation are common presenting signs in heatstroke, and these signs are absent in canine patients whose body temperature elevation is due to a pyrogenic source (e.g. fever).[14] These signs can also help to differentiate heatstroke from exertional hyperthermia and dehydration, as dehydrated dogs will have dry mucous membranes and will be able to stop panting.[4] Mucous membranes are frequently bright red in heatstroke patients, with the exception that some patients in advanced heatstroke will have pale, dry mucous membranes due to advancing cardiovascular shock.

Dogs in heatstroke, and dogs in shock, will quickly begin to pool blood in the intestinal vasculature. The intestinal mucosa of dogs is quite fragile and quickly sloughs into the intestinal tract under the stress of the severely elevated body temperatures of heatstroke. This sloughing provides a third space for blood and body fluids to accumulate, resulting in rapid cardiovascular shock, disseminated intravascular coagulation (DIC), and death. In many cases, the canine heatstroke patient's abdomen will be distended as a result of the accumulation of blood and body fluids in the intestinal tract. At necropsy, the small intestine will be hugely distended, congested, thin-walled, friable, and contain a foul mixture of intestinal contents, blood, and sloughed intestinal epithelium.

Other sequelae of heatstroke include metabolic acidosis, respiratory alkalosis, hemoconcentration, myocardial necrosis, endotoxemia, cerebral edema, seizures, coma, and acute organ failure, particularly hepatic and renal failure.[14] In all of these conditions, the canine will present with altered or absent mental function, which will be obvious to the care provider. Some dogs in heatstroke vocalize loudly (howling rather than barking), and this can be an indicator of abnormal men-

tal function in the absence of obvious traumatic injury.

Treatment of heatstroke is covered well in the prior JSOM article,[4] and includes rehydration, airway support, treatment of secondary events such as shock, disseminated intravascular coagulation (DIC), and organ failure, and most importantly, the re-establishment of normal body temperature. Cooling of the patient should be attempted via cool water (not ice) baths, IV fluid therapy (subcutaneous fluids if IV access not available) and topical application of alcohol to the footpads, ears, axilla, and groin. It is important for the practitioner to be aware that the canine heatstroke patient has temporarily lost its hypothalamic temperature regulatory mechanism,[14] and cooling of the patient should be discontinued once the body temperature lowers to 103 degrees F.[4,9,10,14] For this reason, the body temperature must continue to be monitored closely throughout the treatment of this condition and its sequelae.

MASSIVE HEMORRHAGE

Death from blood loss can occur very quickly, in a matter of minutes in the event that an artery is severed, and penetrating trauma capable of causing massive hemorrhage poses a significant risk to the working canine in both military and civilian environments.[4,6,7] The treatment of life-threatening hemorrhage is divided into three categories in the Prehospital Trauma Life Support (PHTLS) healthcare environment, and we will evaluate these same categories of bleeding in the canine patient: compressible, partially-compressible, and non-compressible.

Compressible hemorrhage is that hemorrhage, which occurs in a location such that manual pressure can be applied to an arterial site proximal to the wound to shut off blood supply to the wound. In canine patients, compressible hemorrhage can occur on the ear, the thoracic limb distal to the elbow (Figure 1), the pelvic limb distal to the knee (Figure 2), and the tail.

These locations are amenable to treatment via direct manual pressure proximal to the wound, or via tourniquet. However, it is the author's experience that most tourniquets designed for human patients are too large to be utilized correctly in the canine patient. For this reason, even compressible wounds in canine patients are often treated by pressure dressing applied directly over the wound, as one would treat the partially compressible wound.

Partially-compressible hemorrhages in the canine patient can occur on the thoracic limb between the elbow and the thorax (Figure 3), including the axillary space, on the pelvic limb between the knee and the abdomen (Figure 4), including the groin, on the tailhead, and on the head and neck.

Figure 1: Thoracic limb distal to the elbow

Figure 2: Pelvic limb distal to the knee

As mentioned above, partially compressible wounds in the canine patient are amenable to treatment via pressure applied directly to the wound and augmented by a pressure dressing applied over the site. Bandages should be applied tightly to these locations and natural anatomical features such as the wing of the ilium (Figure 5) should be utilized as fulcrums in the bandage pattern. A figure-8 bandage can be applied to the pelvis or the thorax of a working canine, but most dogs will require at least five yards of bandage material in order to complete a bandage of this size.

Non-compressible wounds in canine patients are those that occur in the abdominal or thoracic areas. These wounds, as in the human patient, are not amenable to bandaging or tourniquet placement. In some cases, the care provider can see or feel the source of bleeding and apply digital pressure or a hemostat directly to the bleeding vessel. But in most cases, massive hemorrhage in these anatomical areas will result in death of the canine patient in just a few minutes' time, despite the best efforts of the medical care team.

Figure 3: *Thorasic limb proximal to elbow*

Figure 4: *Pelvic limb proximal to knee*

Figure 5: Wing of the ilium

Elastic bandages should be used preferentially, as non-elastic bandages (especially cotton) will expand when wet and may slip from the wound, resulting in failure of the application. Elastic bandages with factory-applied adhesive (Figure 6), are of most effect in applying pressure dressings to canine patients, as the funnel-shaped upper limbs and ventro-dorsally narrow thorax and abdomen tend to cause non-adhesive bandages to bunch up and slip from their original location. Elastic bandages can also be applied on top of a synthetic bandaging tape such as shown in Figure 7, to help hold the bandage application in place.

Canines can be treated with the same hemostatic agents as human casualties. The author has used hemostatic gauze (Figure 8) in canine patients with good hemostatic results. There is a canine version of a

Figure 6: *Elastic bandage 2" and 4"*

hemostatic agent (Figure 9), available in an over-the-counter (OTC) formulation for use in pet dogs and cats. The canine version of this agent is a 25g package that comes in a sealed foil pouch.

The PHTLS manual has an extensive discussion and analysis of the use of intravenous fluids, both crystalloid and colloidal fluids, to treat hypotension from

Figure 7:
4" Bandaging tape

hemorrhage in the pre-hospital human patient.[16] Due to significant similarities in the cardiovascular system of the canine and the human patient, this analysis and the associated findings hold true for the canine patient; namely, that fluid resuscitation of the massive hemorrhage patient should be delayed until after hemostasis is achieved and the patient is under evacuation to a higher level of care.

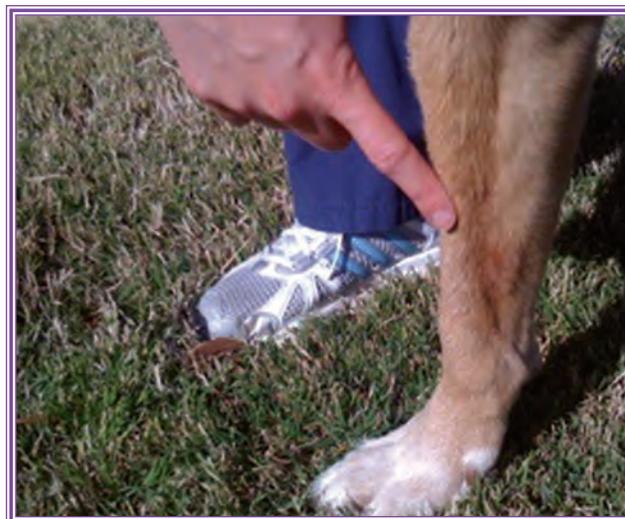*Figure 8: Hemostatic gauze*

Figure 9: Canine hemostatic agent

Once the hemorrhage is controlled and the canine patient is evacuated to a higher level of veterinary care, fluid resuscitation can be addressed in a fashion similar to that noted above for treating dehydration. Standard intravenous fluid products for human patients are utilized in canine patients, including crystalloids such as lactated Ringer's solution (LR), or normal saline (0.9 % NaCl in water), as well as colloidal products such as 6% hetastarch and mannitol.[4,6-15] In addition, there is an FDA-approved hemoglobin based oxygen carrier (HBOC) for the canine patient that is an octamer of the bovine hemoglobin molecule and has been shown to be safe and effective for canine trauma patients over several years of use in veterinary practice in both the United States and Europe.[17] The standard shock dose of the HBOC can be used to support both

fluid volume and blood pressure in the canine patient, without the requirement of canine blood typing.

Blood transfusions between dogs are possible at higher levels of veterinary care. Standard human blood sets and citrated collection vials can be utilized to collect and transfuse the sample from one patient to another. While the details of canine blood typing and blood transfusions would occupy an additional paper, the author would like to point out that due to the limited range and distribution of blood types in canines (approximately 50% of dogs are positive for the most important canine antigen DEA 1.1), the lack of alloantibodies in dogs, and the unlikelihood of prior transfusion in a given dog, a one-time transfusion between two dogs can be achieved under relatively austere conditions, with limited risk of transfusion reaction in the recipient dog.[18] This is, in fact, a common occurrence in private veterinary practice in locations distant from a canine blood bank. The use of HBOC is preferred for treatment of canine patients with acute hemorrhage blood loss,[17] given the fact that the HBOC is stable for long periods of time at a large range of temperatures and does not require cross-matching or cause mismatch transfusion reactions.

VASCULAR ACCESS

All of the conditions discussed in this article require vascular access in order to provide definitive treatment. The veins of working canines are usually prominent and a skilled medical practitioner will be able to place an intravenous catheter with ease in the canine patient. The most accessible veins for intravenous catheterization include the cephalic vein on the thoracic limb (Figure 10), the saphenous vein on the lateral surface of the pelvic limb (Figure 11), and the

Figure 10: Cephalic vein

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external jugular vein on either side of the neck at the jugular furrow.

The cephalic and saphenous veins are of sufficient size in all working canines that they can accommodate a 20ga x 1.5" catheter. These veins are large enough for 18ga or 16ga catheters in some large, lean dogs. The jugular veins should be of sufficient diameter to accommodate anything smaller than a 14ga catheter.
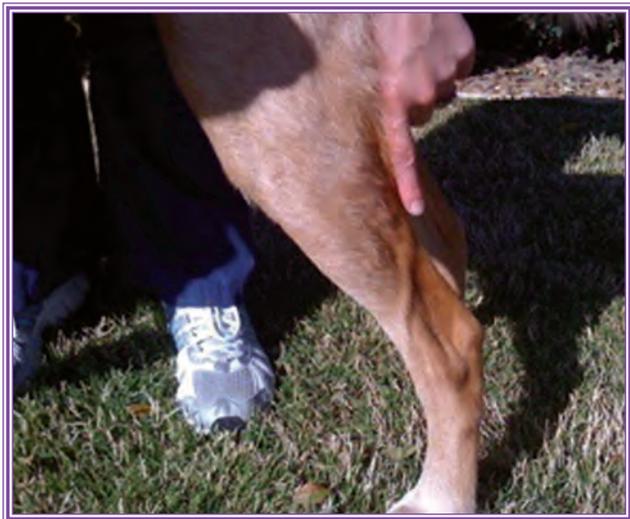
Figure 11: Saphenous vein

Catheters can be taped in place using standard 1in. athletic tape. In ideal situations, the leg would be clipped of fur and the leg prepped with surgical disinfectant prior to IV placement. In situations where clippers are not available, the skin and fur can be disinfected with rubbing alcohol or surgical disinfectant without clipping. Soap-containing solutions should be avoided in this instance, as these will result in a slippery hair surface that will not hold tape.

Standard heparin-locks and intravenous fluids and lines can be utilized for the canine patient as discussed above.

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Dr. Wesley M. Taylor holds degrees from Rice University (BA 1988) and Texas A&M University (DVM) and is a Diplomate of the American College of Laboratory Animal Medicine. He has served as the Assistant Director of Laboratory Animal Medicine at the University of Mississippi Medical Center and as the Chairman of Primate Medicine and Surgery at the New England National Primate Research Center, Harvard Medical School. During this time, he also served as an officer in the Mississippi Air National Guard. For the last 10 years, Dr. Taylor has been in private practice in the north Texas area, where he practices general and emergency veterinary medicine and surgery, and serves as a veterinary consultant at the Texas Research and Education Institute (TREI) and at the University of North Texas Medical Center. Dr. Taylor has over 16 years of experience with working canines and lectures frequently to law enforcement groups on emergency medicine and surgery of the canine officer, and he serves as a veterinary consultant to several Texas area law enforcement agencies. Dr. Taylor serves as veterinarian and instructor in Tactical Combat Casualty Care (TCCC) training courses held for the Operational Medicine Fund of the Presbyterian Healthcare Foundation and for Advanced Medical Training.

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