Technical Large Animal Emergency Rescue, Inc.

TLAER™

Accidental Hypothermia in the Horse

A Review for Emergency Responders*

Introduction

During many equine emergencies initial assistance is concentrated on removing (rescuing) the victim from the incident site, and taking care of critical medical needs later. In the case of hypothermia such prioritization of the rescue effort has sometimes fatal consequences. Also, once the equine victim is removed from the hypothermia-causing environment, well meaning but misunderstood efforts to restore body temperature can be counterproductive resulting in a more severe hypothermic state.

The purpose of this review is to provide an overview of the mechanisms responsible for thermoregulation and hypothermia, and to assist the emergency responder with information that may help save the life of the hypothermic horse. Little information exists on accidental hypothermia in the horse. Therefore, observations on the mechanisms of hypothermia in other species are also mentioned.

Body temperature

Body temperature is really body *temperatures*.

The body core (organs, large blood vessels, central nervous system) can have a different temperature from surface temperature, i.e., peripheral or shell (muscles, fat, skin, hair coat) , and these temperatures

*Contact: Tomas Gimenez, Dr. med.vet. TLAER™, Pendleton, South Carolina, USA www.tlaer.org, tlaer@bellsouth.net, February 2011

tend to oscillate under the influence of several variables. Fortunately for us mammals the thermoregulatory center of the brain in the hypothalamus receives input from temperature sensors across the organism and performs two main functions:

a) It sets the average body temperature (core temperature), and allows it to oscillate only ± 0.2 °C (0.36 °F), whereas surface (shell) temperature is allowed to oscillate up to ±4.0 °C (7.2 °F) before corrective mechanisms kick in.
b) Normal core temperature is essential to preserve body functions. Therefore, the brain will do everything it can to maintain normal core temperature, even at the expense of surface/peripheral temperature, to maintain life.

The most practical way to measure core body temperature in the horse is by measuring rectal temperature. It is important to keep the tip of the thermometer in good contact against the wall of the rectum for the necessary amount of time, and not inserted in the feces. The rectal temperature should be interpreted with caution, since there is a lag between rectal and core temperature due to the temperature flux in hypothermia.

Maintenance of core temperature

Horses have the ability to maintain normal core temperature in extreme cold climates. The thick haircoat and subcutaneous fat allows the Yakut horses in Siberia to tolerate temperatures of -68 °C (-90 °F) in their natural habitat. The peripheral shell composed of muscles, fat, skin, and haircoat helps to maintain a constant core temperature by either releasing or preventing the loss of heat from the core (Figures 1 and 2). The rate of heat loss from the core to the environment will vary depending on the insulating capacity of the shell including skin thickness, amount of subcutaneous fat, length and density of the hair, and piloerection.

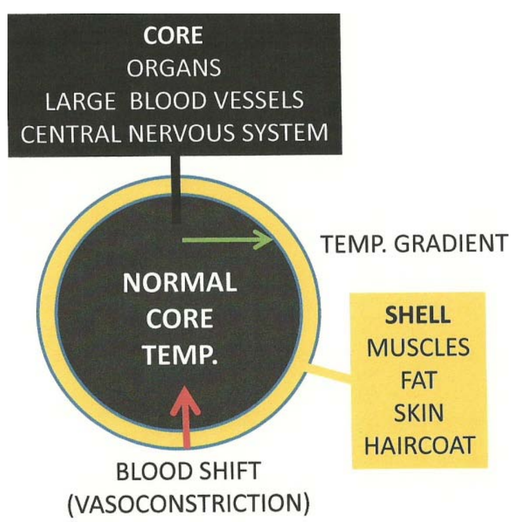

Figure 1. Core temperature regulation during cold weather.

During cold weather the organism will minimize the dissipation of core body temperature through insulator mechanisms (muscle, skin, fat, haircoat, piloerection) and vasoconstriction.

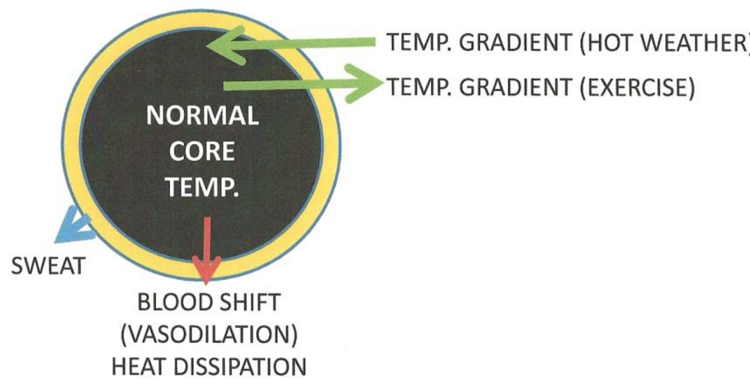

Figure 2. Core temperature regulation during hot weather or exercise.

Core temperature will tend to increase during both hot weather (increased environmental temperature) or exercise (increased temperature from muscle contraction). In either case the thermoregulatory center will maintain normal core temperature by dissipating heat through peripheral vasodilation and loss of water (sweat).

Hypothermia

Heat loss > Heat production = Hypothermia

Types of hypothermia

Accidental hypothermia is divided into three types:

> ***Acute*** hypothermia, the subject of this review, also known as immersion hypothermia, caused by the sudden exposure to cold such as exposure to cold water or mud.
>
> ***Exhaustion*** hypothermia caused by exposure to cold in conjunction with lack of food and exhaustion.
>
> ***Chronic*** hypothermia found mainly in old individuals.

The normal body (core) temperature in the mature horse is 37.5-38.0° C (99.5-100.4° F). Any temperature below 37.5° C (99.5° F) is considered hypothermia in the mature horse. In humans hypothermia is defined as a drop in core temperature below 35° C (95° F).

Studies on immersion hypothermia in humans have shown that death will occur in 70% of cases with a core body temperature of 30° C (86° F), and in 90% of cases with a core body temperature of 26° C (78.8° F). The ultimate cause of death during hypothermia appears to be cardiac failure with asystole or ventricular fibrillation.

Vasoconstriction will help isolate the thermal core to preserve normal core temperature. When core temperature continues to drop, vasoconstriction can no longer compensate for the periphery's heat loss and shivering will appear to help maintain core temperature.

Water is an excellent conductor of temperature. Wetness of body surface will contribute to loss of core temperature through conduction more than any other mechanism (Figure 3). Water will conduct heat away from an object twenty-five times faster than air. A human body will lose heat in 26.5° C (80° F) water at the same rate as it does in 5.5° C (42° F) air.

Horses will rarely suffer from hypothermia under normal conditions. It is when a large percentage of body surface is in direct contact with a conduction agent like water that the loss of heat will exceed heat production by the body.

The rate of body temperature loss in a horse immersed in water or mud is not known. However, studies have been performed to measure the rate of core temperature loss during general anesthesia which alters thermoregulation in the hypothalamus. Horses under general anesthesia for more than 45 minutes lost a mean body temperature of 0.8$\pm$0.6° C (1.44$\pm$1.08° F) per hour (range 0-2.4° C, 0-4.32° F). Wetness of body surface strongly contributed to loss of body temperature during general anesthesia.

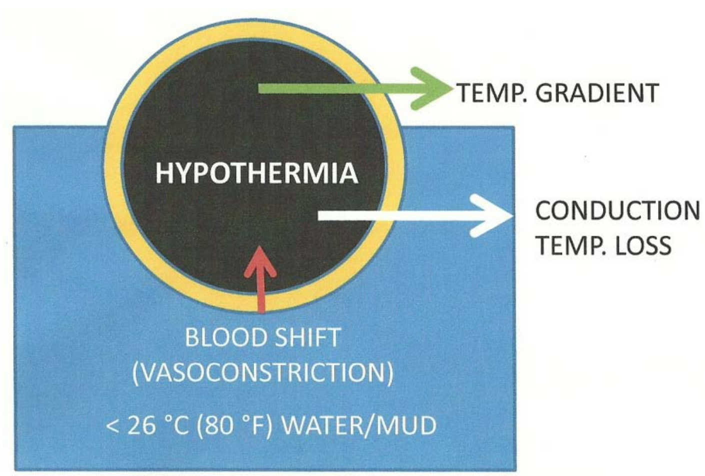

Figure 3. Core temperature loss during immersion in cold water or mud.

When the organism is in direct contact with cold water or mud it will eventually become hypothermic in spite of efforts to minimize heat dissipation through vasoconstriction and shivering.

Degrees of Hypothermia

Mild Hypothermia, known as Mild Therapeutic Hypothermia (MTH) has been used in humans since 1952 for its ability to reduce neuronal loss, provide cerebral protection after severe traumatic brain injury, and for neuroprotection during vascular surgery. Hypothermia for therapeutic purposes is not without potential serious side effects, and is only used under very close monitoring . Therapeutic hypothermia is classified as mild, moderate or severe/profound depending on metabolic/clinical changes that occur at different core temperatures.

Although there is no corresponding classification of hypothermia in the horse, the following table (Table 1) may prove to be a useful guideline to document the severity of hypothermia during accidental immersion hypothermia in the horse.

Type	Core temp.	Signs
Mild	**36-33° C 96.8-91.4° F**	**Shivering Tachycardia Tachypnea**
Moderate	**32-28° C 89.6-82.4° F**	**Violent shivering Blue mucous membranes**
Severe/Profound	**27-20° C 83.6-68° F**	**Cellular metabolism shuts down Recumbency Atrial fibrillation**

Table 1. Classification of degrees of hypothermia.

Risk Factors affecting the onset and severity of hypothermia

Dehydration – Most horses suffering from acute hypothermia also suffer from dehydration.

Poor body condition – Horses in poor body condition are more susceptible to hypothermia due to a reduced layer of insulating subcutaneous fat.

Age – The ability to generate heat, also known as basal metabolic rate, decreases with age in all mammals studied. However, the horse has one of the lowest decrease rates of heat production through life (40-20 Cal/day/Kg) when compared to other species (human, swine, rat, guinea pig, cattle, chicken)

Body surface/volume (mass) ratio – The larger the body surface relative to body mass, the more core temperature will be lost across the body surface. This explains in part why donkeys and small horses (foals, ponies) are more susceptible to hypothermia than mature horses.

Drugs – General anesthetics (anesthetic-induced vasodilation), acepromazine, α2-adrenergic agents

Rough handling – Rough handling of the profound hypothermic patient after the rescue can trigger ventricular fibrillation and cardiac arrest.

Clinical signs/Complications

Table 2 shows some of the more common clinical signs and complications of hypothermia.

Event	Occurrence
Rectal temperature	Less than 37.5-38.0° C (99.5-100.4° F)
Shivering	Early during hypothermia, mainly in extremities
Tachycardia	Early during hypothermia followed by bradycardia
Dehydration	Found frequently in horses trapped in various environments
Decreased capillary refill	Consequence of dehydration
Cold diuresis	Peripheral vasoconstriction causes increased blood flow to the core with higher renal blood flow
Arrhythmia/Ventricular fibrillation	Can occur as a result of rough handling during rescue even under mild or moderate hypothermia. Also known as “postrescue collapse” or ”rewarming shock”
Myoglobinuria	A sign of muscle cell damage. Urine has red wine color
Recumbency	A sign of severe hypothermia
Pneumonia	Sepsis is a common consequence of hypothermia

Table 2. Some common clinical signs/complications of hypothermia.

Rewarming the hypothermic horse

Rewarming of the hypothermic victim should only be performed by personnel who have a clear understanding of the adverse effects of improper rewarming. The hypothermic horse may die not as a result of hypothermia during immersion, but of improper handling and/or rewarming procedures during rewarming.

Restoring body temperature.

The main focus of rewarming the hypothermic horse should be to restore core temperature. Peripheral warming without simultaneous core rewarming can be counterproductive (Figure 4). A horse with a rewarmed and dry coat can be suffering from more severe hypothermia than a horse with a wet and “cold” feeling coat. Use of a forced air warming device had no effect on core temperature during recovery in anesthetized horses. Jean Pierre Moricheau-Beaupré, a surgeon in Napoleon’s Russian campaign was already aware of the potentially adverse effects of surface rewarming: *"we must not…transport the body into a heated place, or immediately apply to it warm substance…"*

The "afterdrop" effect

A further decrease in core temperature , or continued cooling, after the rescue is known as the afterdrop effect, and is a phenomenon of conductive heat loss. The afterdrop can occur during:

a) Shivering which stimulates a shift of blood to the musculature, or
b) During surface warming which will stimulate peripheral vasodilation.

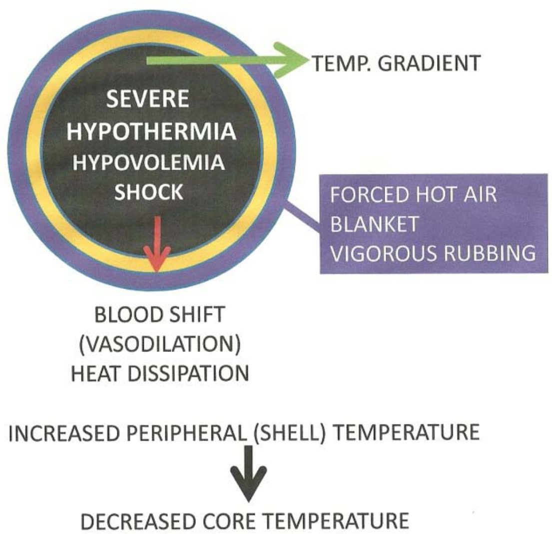

Figure 4. Severe hypothermia during peripheral rewarming in the absence of core rewarming.

When measures are taken to increase peripheral (shell) temperature, the thermoregulatory center (hypothalamus) senses the increase in peripheral temperature and responds by stimulating vasodilation with warming of the shell at further expense of the core. This response by the hypothalamus in the absence of a simultaneous effort to restore core temperature can result in critical core hypothermia, hypovolemia, shock and death.

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Core rewarming

No treatment is more effective in hypothermia than core rewarming. Core rewarming can be achieved most effectively through the administration of warm fluids intravenously and through a warm enema.

The large animal veterinarian should initiate administration of warm intravenous fluids to the hypothermic horse as soon as possible. Intravenous fluids are important not only to restore core normal core temperature but just as important to rehydrate the horse. Intravenous fluids should be warmed before administration, which can be achieved by placing the fluid bags in a water bath.

Ideally fluids should be administered at a temperature of 40° C (104° F), but no less than 33° C (91.4° F). Fluid temperatures at or above 47° C (116.6° F) can cause thermal damage to red blood cells.

Core rewarming can also be enhanced through enema and warm fluid administration per nasogastric intubation.

Surface (convective) rewarming

Surface rewarming can be used as an adjunct to core rewarming through the use of forced hot air, heat lamps, heating pads, blankets, and protecting the victim from the wind. Forced hot air(active surface rewarming) was more effective than blankets (passive surface rewarming) in human hypothermic patients receiving warm iv fluids and warmed, humidified oxygen. Vigorous rubbing should ***never*** be used for surface rewarming because it can damage frozen cells.

On some occasions, however, surface rewarming may be the only choice for a number of reasons (limited resources, financial, etc.). Although a digital thermometer did not register the initial rectal temperature the day of the incident, a donkey received surface rewarming only (warm environment, blankets), antiprostaglandins and antibiotics. Forty eight hours later the rectal temperature was 35.4° C (95.8° F, Deke, 2011)

Additional therapy

Depending on the severity and /or complications of hypothermia, the large animal veterinarian may decide to administer:

Supplemental oxygen through the nose

NSAIDS (antiprostaglandins)

Antibiotics

Handling

Careful handling of the hypothermic horse is extremely important to help prevent cell damage and heart dysfunction (arrhythmia/heart attack).

Field guide

Table 4 offers a field guide for incidents involving accidental immersion in the horse. Its main focus is to restore core temperature as soon as possible.

1	Scene sizeup
2	Gather information Duration of immersion?
3	Assess dehydration
4	Check rectal temp. if possible
5	Establish vein access (large animal vet)
6	Initiate core rewarming iv fluids at 104° F (average) (large animal vet)
7	Perform rescue **HANDLE ANIMAL GENTLY**
8	Check rectal temp.
9	Check vital signs
10	Initiate surface rearming Forced hot air best Blankets OK **NO RUBBING**
11	Assess need for further Core rewarming (enema/nasogastric, large animal vet)
12	Transport to veterinary Facility

Table 3 Field guide for accidental immersion hypothermia in the horse

Hypothermia and Death

Under field conditions, the hypothermic horse should not be declared dead unless all efforts to restore core temperature have failed. Core temperature is not a reliable indicator of survival as demonstrated by many cases of humans with profound hypothermia. The only definite criterion of death is failure to respond to core rewarming. The following quote is well known quote in human hypothermia resuscitation: “A patient is not dead until he is warm and dead." A woman with a core temperature of 9° C (48.2° F) recovered after one hour without cardiac activity or respiration.

At the cellular level, potassium is a good indicator of prognosis in hypothermia. After the onset of hypothermia a shift of extracellular potassium occurs resulting in hypokalemia (< 2.5 mmol/L). During more severe stages of hypothermia tissue damage and metabolic acidosis will occur with a release of intracellular potassium resulting in hyperkalemia (> 4.8 mmol/L). Hyperkalemia during hypothermia has a poor prognosis, and can be considered as an index of irreversible hypothermia. Death is generally attributed to ventricular fibrillation.

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