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METABOLIC PROBLEMS SEEN IN ENDURANCE RACES AND CROSS-COUNTRY COMPETITIONS

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Early recognition and appropriate management of metabolic problems in equine athletes is critical if ideal medical outcomes are to be achieved. These problems are relevant particularly to horses participating in intense sports such as the speed and endurance phase of eventing competitions, competitive trail and endurance riding/racing and marathon driving present challenges for veterinarians, competitors, stewards and organisers. Despite recent advances in veterinary control at equestrian competitions and medical strategies for management of problems metabolic disorders occur relatively frequently. The challenge to the veterinarian in diagnosis and management of these disorders problems under field conditions, often in the absence of diagnostic clinical pathology services, can be challenging.

A variety of metabolic syndromes have been described as being the result of disturbances in thermoregulatory, fluid, electrolyte and acid-base balance as a consequence of exercise. Underlying and often unrecognised pre-existing pathology may also contribute to the development, severity and ultimate outcome of a particular problem in afflicted horses. The most commonly recognised problems associated with these changes include:

- Dehydration, hyponatremia, hypocloremia, hypocalcaemia
- Synchronous Diaphragmatic Flutter (SDF) (aka thumps)
- Metabolically induced myopathies e.g., cramps, 'tying-up'
- Laminitis (founder)
- Colic
- Exhausted horse syndrome
- Post-exhaustion syndrome

An understanding of the pathophysiology of metabolic disorders is considered essential if early recognition and appropriate management are to occur. A variety of factors, usually in combination, are key to the development of these metabolic problems. Experienced clinicians note that it is common for similar horses under the influence of similar exercise stimuli to develop different metabolic disorders. For example, two horses competing under similar conditions at the same endurance ride may show signs of dehydration and delayed recovery following the competition. However, one of the horses may go on to develop colic whereas the second horse develops laminitis.

The major factors contributing to metabolic disorders in response to these types of exercise include:

- heat production during exercise
- water loss via skin (sweat) and respiratory routes
- electrolyte losses in sweat
- fluid and electrolyte redistribution within the horse's body
- energy depletion
- splenic contraction leading to hemoconcentration
- metabolic alkalosis resulting from disproportionately large losses of chloride in sweat.

During exercise the demand for energy increases. The production of energy from metabolic sources results in relatively large heat loads being produced. This results from the fact that only 20% of the energy consumed results in mechanical force (i.e., locomotion) with the remaining 80% liberated as metabolic heat. This heat must be dissipated if thermal overload is to be avoided. This is achieved by the evaporation of fluid from body surfaces (sweat from the skin and water from the respiratory tract). In
hot, humid weather this is the primary method of cooling. In cooler weather heat can be dissipated through direct conduction and convection from body surfaces. The requirement for horses to cool via sweating creates two significant metabolic demands. The redistribution of blood flow to the subdermal capillary bed results in less blood being available for other organs. In addition the loss of water and electrolytes in the sweat may result in dehydration and significant changes to the acid-base balance. Horses exercising intensely in conditions where the ambient temperature is 22°C and the relative humidity is 75% have been reported to lose up to fifteen litres of sweat per hour in an attempt to maintain body temperature within the normal range. In general endurance horses rarely have rectal temperatures exceeding 40.5°C - mostly they are maintained at less than 39°C. Eventing horses undertaking the speed and endurance phase of the competition may have rectal temperatures as high as 43°C. Certainly if such temperatures are maintained for more than tens of minutes they may be life threatening. Similarly if the core temperature is above 40.5°C for more than a few hours this too may be life threatening.

Signs of dehydration may include increased 'skin tenting' times. This test should be performed on the skin of the neck just anterior to the supraspinatus muscle. Increased tenting times are normally not evident until the horse has suffered at least 5% loss of bodyweight due to dehydration. When the tenting time increases to ~3 seconds may indicate a loss of about 10%. The hemococoncentration created by the loss of fluid greatly increases blood viscosity. This increased viscosity, the preferential shunting of blood to the skin from other organs for thermoregulation, and the acid-base changes associated with the loss of electrolytes combine to alter the normal perfusion of tissues. This decrease in tissue perfusion is considered to be a possible contributing factor in the development of laminitis, metabolic muscle myopathies, and colic. Normal thermo-regulation is also compromised since reduced tissue perfusion results in less heat being removed from tissues and reduced blood flow to the skin for cooling.

The effects of dehydration may be added to by the haemoconcentration occurring as a result of the splenic contraction occurring in response to exercise. This further increases blood viscosity potentially adding to the decreased tissue perfusion.

The primary anions lost in sweat are Na+, K+, Ca++, and Mg++. Of these Na+ and K+ are the most important since they are present in the highest concentrations. The primary cation is Cl- with sweat being hypertonic relative to plasma soon after commencement of exercise. Sweat then is likely to become isotonic as exercise continues. Thus, losses of large volumes of electrolyte rich sweat may result in substantial decreases in exchangeable ions during exercise. These fluid and electrolyte losses may fail to stimulate the central osmotic receptors for drinking and thus dehydrated horses may not have a strong stimulus to drink.

Another effect of the electrolyte loss in sweat is metabolic alkalosis. This results from the fact that sweat is relatively rich in chloride. Thus, in order to maintain electroneutrality the horse retains bicarbonate with resultant alkalosis. The metabolic alkalosis results in increased binding of Ca++ to plasma proteins thus decreasing the concentration of ionised Ca++. This decrease in ionised Ca++ results in an increase in neural irritability. This process is believed to result in increased irritability of the phrenic nerve as it passes over the cardiac atrium. The proposed progression is that the phrenic nerve is stimulated by the polarisation-depolarisation cycle of the myocardium. As the phrenic nerve has a motor input to the diaphragm the net result is a process whereby the diaphragm contracts in response to each cardiac contraction producing a 'diaphragmatic flutter' synchronous with the cardiac cycle. This disorder is commonly referred to as thumps since the diaphragmatic flutter is associated with a hiccup-like thumping sound.

Exercise induced losses of fluids and electrolytes may induce changes the skeletal muscles, particularly those directly involved in the exercise. Affected horses have an increased risk of muscular fasciculations and cramps. More serious effects may include exertional rhabdomyolysis ('tying up') and other myopathies. In severe cases the myocardium may be affected also with potentially life threatening consequences. Considering the systemic effects of fluid, electrolyte, acid-base and thermoregulatory derangements cardiac dysrhythmias are relatively common in horses undergoing veterinary assessments/checks during competition.
The gastro-intestinal system is may be influenced dramatically by the imposts of exercise. Blood flow redistribution to key organs directly involved in locomotion and thermoregulation results in dramatic decreases in blood flow to the gastrointestinal tract. Thus GI disturbances are likely to be an expected consequence in some horses undertaking of intense, prolonged exercise. The effects of the exercise may be manifest as reduced gut sounds during and after competition; such findings are common in endurance horses. More severe consequences such as colic are common in horses suffering from metabolic problems in response to competition. Not surprisingly when evidence of dehydration is marked, the risk of disorders such impaction colic are increased. This occurs because fluid is drawn out of the GIT to augment the circulating volume, thus increasing the viscosity of the ingesta. Additionally the reduction in GIT blood flow results in diminished gut motility.

Energy depletion, particularly diminution of the muscle and liver glycogen stores, may become a significant risk for medical problems during prolonged exercise. These problems appear more prevalent when ambient conditions are cool-cold and wet. This is in contrast to hot-humid conditions when fluid-electrolyte-thermoregulatory disorders should be expected to prevail. Thus, many of the signs of 'fatigue' during cool-wet conditions are likely to be due the combination of energy depletion with or without reduced tissue perfusion.

When a veterinarian is required to treat a horse for a metabolic problem at a competition, it is important to consider the events that contributed to the development of the problem. As discussed these will most likely relate to fluid and electrolyte losses, possibly hyperthermia and energy depletion. Horses with signs of poor recovery, myopathy, SDF or some associated disorder, but with few signs of dehydration, will usually benefit from administration of fluids (per stomach tube or IV). Horses that are suffering severe hyperthermia will benefit greatly from this form of therapy and also aggressive cooling. Dousing/sponging the horse with large volumes of ice cold water, allowing this water to warm and then scraping it off the horse's body will result in significant conductive heat loss. If this process is repeated every few minutes core temperature can be reduced by several degrees over 10-30 minutes. This alone may be a life saving intervention and its beneficial effects should not be underestimated.

Fluids can be given orally at the rate of 4 to 6 litres every 30-60 minutes until the horse appears to be recovered to normal. Oral fluids should be isotonic and preferably at or near room temperature. A solution containing 40g sodium chloride and 30g potassium chloride per 10 litres is recommended. If energy depletion is considered to be significant addition of 250ml to 500ml of 50% glucose solution may supply some of the caloric deficit. If the risk of colic is too great or the horse fails to show any signs of recovery, or worsens within 30 minutes following administration of oral fluids, intravenous fluid therapy should be initiated. Fluids suitable for intravenous use include Hartmann's or Ringer's (± 5% glucose/dextrose), or normal saline (with up to 25 mmol KCl/L ± 5% glucose/dextrose). In general solutions rich in lactate or bicarbonate should be avoided. Horses with SDF (thumps) will usually respond to fluid volume expansion (especially the fluids rich in chloride) as these assist in normalising the acid-base balance. If SDF is severe or prolonged, administration of 250-500 ml calcium borogluconate diluted 1:4 in Ringer', Hartmann's or normal saline solutions is often effective.

Intravenous fluids should be given at the rate of up to 20 litres in the first hour, reducing to 10 to 15 litres per hour after that, until the horse appears to have recovered sufficiently. Volumes of 40 to 60 litres or more may be required to replace deficits and allow for maintenance during the administration period. As a rule many experienced clinicians suggest that intravenous catheters should be 14 g. Given that the high flow rates recommended may be difficult to achieve using gravity feed alone administration using pressure or pump is recommended. Insertion of catheters into more than one vein will increase the potential to meet appropriate rates of administration. It is important that the clinician ensure that the tubing is of sufficient inside diameter to allow for these high flow rates. Fortunately horses in these situations have minimal risk of succumbing to pulmonary oedema; thus the benefits of high fluid rate infusions far out way the risk of this side-effect. In general most experienced clinicians minimise the use of many of the pharmacotherapeutic agents that may be contemplated in similar clinical problems occurring in horse NOT subjected to prolonged exercise. Thus it is wise to be extremely cautious/restrictive when considering administration of for example, acepromazine, opioid analgesics, NSAIDs, diuretics. As a rule these agents are contraindicated in dehydrated horses with electrolyte imbalances. In contrast, the rapid administration of high volumes of balanced electrolyte solutions will
reverse the dehydration and electrolyte deficits, thereby allowing at a later time, the safer administration of any pharmaceutical agents indicated for treatment of any secondary conditions. Clinical experience indicates that the clinical signs of these 'secondary' conditions abate in response to rehydration alone; this obviates the need for administration of additional pharmacotherapeutic agents.

Clinicians should be aware that horses receiving high rates of intravenous fluid administration will not be inclined to drink; however, a good prognostic the desire to eat. Thus if a horse is eating, yet not drinking, but appears well hydrated discontinuation of intravenous fluid therapy may be considered.

A possible check list of the equipment considered appropriate for a veterinarian serving in a professional capacity at an speed and/or endurance competition is provided below. This list is designed to allow the veterinarian to deal effectively, in the field, with the disorders outlined in this paper;

- halter and lead rope
- twitch
- stethoscope
- thermometer
- refractometer
- assorted syringes and needles
- local anaesthetic
- 14 g catheters and IV tubes (large bore)
- stomach tube, funnel, and pump
- assortment of buckets
- large volumes of water (for 'sponging down' horses and drinking)
- large volume of ice
- electrolyte solutions for oral administration
- IV fluids (large volumes as one treatment may require 40-60 L)
- potassium chloride solution
- 50% dextrose solution
- calcium borogluconate solution
- suture pack
- mineral (paraffin) oil
- bandage materials
- NSAID's
- sedatives (alpha agonists)
- opioid analgesics
- diuretics
- method for euthanasia

In summary, the 'in-field' treatment of metabolic disorders at endurance type events is optimised if the clinician has a fundamental understanding of the effects of the fluid, electrolyte and energy losses and thermoregulatory imposts that contribute to the development of the disorders described herein. Early recognition and treatment is essential if the most favourable outcomes are to be achieved. In general, administration of oral and/or intravenous fluids, even in the apparent absence of 'clinical' dehydration, in the quantities outlined above, will often alleviate the disorders without any other specific therapy being provided.