Influence of feeds and feeding on incidence of laminitis

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Laminitis is truly a global condition of horses and ponies with major welfare implications. In 2004 there was a special issue of the Equine Veterinary Journal devoted to the topic and an international Laminitis research meeting (sponsored by the American Association of Equine Practitioners with others); in 2005 WALTHAM together with Virginia Tech held an International Symposium on Innovative Nutritional, metabolic and genetic countermeasures to equine laminitis reflecting this conditions importance for Vets, owners and carers throughout the world.

Laminitis is often thought to be a systemic disease, which manifests as a condition of the foot (see *Bailey* et al. 2004). Currently there are perhaps 3 main theories regarding the pathogenic/etiologic mechanisms involved– and within each of these theories are multiple factors that might be implicated (and it is more than likely that some of these may be interrelated):
1. Primarily related to a disturbance in the blood flow to the feet - period of ischaemia of the sensitive dermal lamellae followed by reperfusion injury (*Hood* 1999).
2. Related to inflammatory, toxic, metabolic, and or enzymatic mechanisms : in particular those that activate matrix metalloproteinases (MMPs) which break down the basement membrane bonding the dermal to the epidermal lamellae (*Pollitt* et al. 2003).
3. Related to traumatic/mechanical factors.

Importance of nutrition

Whilst the precise causes are not yet fully understood, recently there have been a number of advances in our knowledge of this important and debilitating condition (see *Bailey* et al 2004). It has however, been estimated that over 50% of cases develop secondary to gastrointestinal disorders, including grain overload, ingesting 'lush' pasture, colitis and diarrhoea.

Typical scenarios of nutritionally associated laminitis include:
1. Ponies (who may be inherently insulin resistant and this may be made worse due to them either being obese or in the process of losing weight or having been fed traditional starch and sugar based diets long term) – being turned out onto certain pastures.
2. Any horse or pony having access to too much cereal/starch – can cause an acute very severe episode or perhaps more commonly may be responsible for subclinical laminitis in high performance horses – often a hidden problem.
3. Certain horses (including various pony breeds, the Morgan horse, European warmbloods and American saddlebreds), not necessarily on 'lush' pasture, but perhaps with insulin resistance (due to prior starch and sugar based diets, episode(s) of inflammation, period of enforced inactivity, weight associated factors, severe stress, genetic predisposition and various other factors).
4. Horses or ponies that eat black walnut shavings (used for bedding in some countries).

According to a survey in the US the most common perceived cause was the ingestion of 'lush' pasture.

Possible Sequence of events of grass-triggered laminitis

Turning certain ponies or horses out onto 'lush' or 'stressed' pastures especially in the spring and autumn is thought to be a common predisposing factor and currently it is believed that high levels of water soluble carbohydrates (which include the simple sugars as well as the more complex storage carbohydrates: fructans) and/or starch may be involved in this process. As noted by *Bailey* et al 2004 'fructans, a group of fructo-oligosaccharides of varying molecular size and branching structure are produced as a storage carbohydrate in grasses and levels increase under climatic conditions favouring photosynthesis over growth (*Longland* and *Cairns* 1998, *Longland* et al. 1999). These conditions (bright sunshine during the day with cool nights) are similar to those associated with increased incidence of pasture laminitis (*Katz* et al. 2000). It is thought that as for other mammals the horse does not have the necessary enzymes to digest fructans directly within the small intestine. Although some bacterial fermentation may occur, the majority of the fructans therefore pass into the hindgut. Here they are readily fermented, in a similar manner to starch that escapes digestion in the small intestine (following the ingestion of too large a cereal based meal or high levels of starch in certain plants). A schematic diagram as to the possible consequences of this is shown in figure 1. It is important to note that whilst much of the current research is concentrating on the role of fructans in pasture associated laminitis other potentially rapidly fermentable carbohydrates may be as or more important in some cases.

Role of insulin resistance

Insulin resistance is often considered to be a decrease in tissue responses to insulin or more simply as a diminished ability of a given concentration of insulin to exert its normal biological effects (see *Kronfeld* et al. 2005). A specific quantitative method for measuring insulin resistance, the minimal model, has demonstrated compensated insulin resistance in 7 ponies that have previously had pasture laminitis in contrast to seven that had never had the disease (*Treiber* et al. 2005a). Glucose is important in maintaining lamellar integrity and has been shown to be essential for hoof explants in culture. Culture without glucose or inhibition of glycolysis also causes basement membrane zone separation under tension (*Pass* et al. 1998). A similar mechanism may operate in natural cases of laminitis where basal cell uptake of glucose may be compromised. It has been well recognised that obese animals especially ponies are more prone to laminitis; this may in part be linked with mechanical trauma but is likely that the increased risk is more appropriately attributed to the development of insulin resistance (*Treiber* et al. 2005b). It has been suggested that there may in fact be a progression of insulin resistance in laminitic prone ponies from a compensated insulin resistance

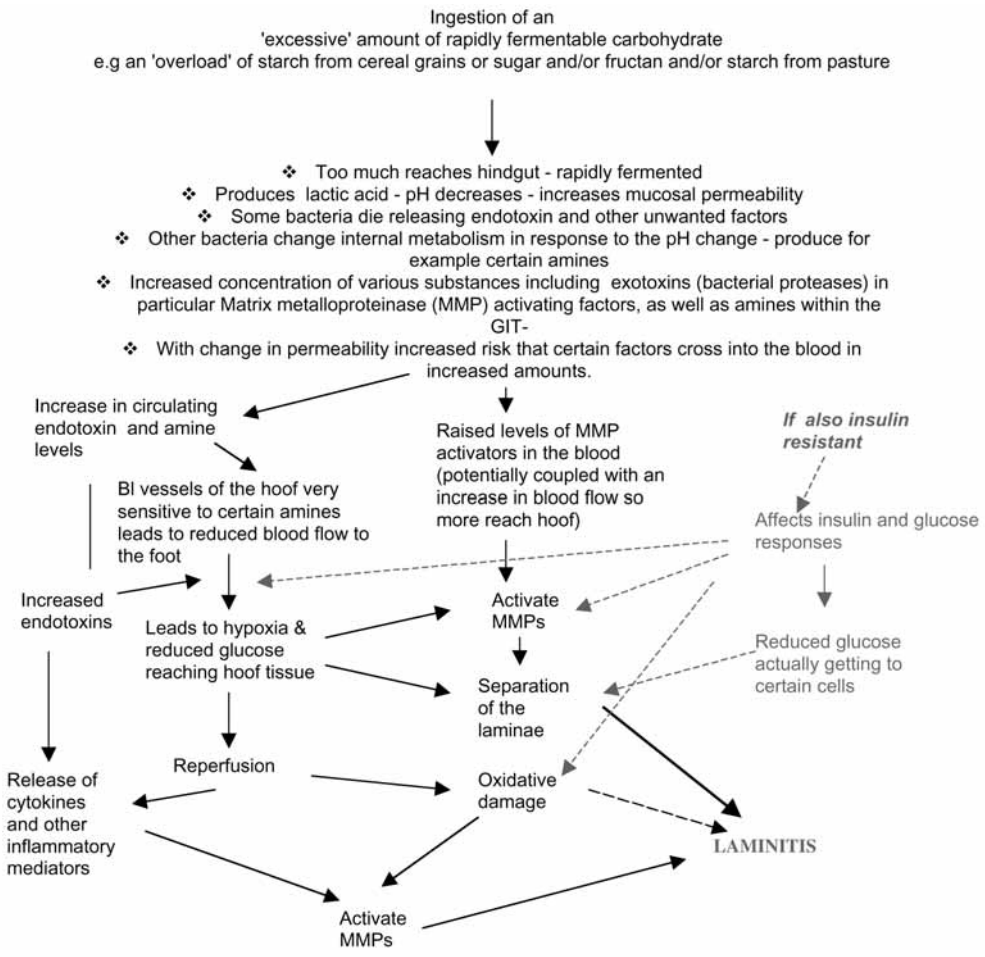

Fig 1 showing some of the possible sequences of events in cereal and grass associated laminitis plus the potential influence that insulin resistance may have. See *Bailey* et al. 2004, *Kronfeld* et al. 2005, *Longland* et al. 1999, *Pollitt* et al. 2003, and *Weiss* et al. 1998.

(being a predisposing factor in healthy but genetically predisposed ponies) through to a decompensated insulin resistance later in the course of the disease (*Hess* et al. 2005).

This review

Although we have made great progress in understanding this complex condition there is still a lot that we need to confirm and to understand. This review will look at some of the work recently undertaken in key areas including the effects of feeding fructans; how much may be ingested under field conditions and could pasture starch be as or more important than fructans. This review will therefore provide an overview of possible ways that feeds and feeding may influence the incidence of laminitis.

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