The laminae are the attachments between the bony skeleton of the limb and the hoof. They surround the pedal bone attaching it to both the hoof wall and the sole. To enable the hoof wall to grow the laminae constantly detach and re-attach at a cellular level allowing the outer laminae to slide over the inner laminae as hoof horn grows towards the ground. Laminitis refers to inflammation of these laminae and if severe may result in detachment of the hoof wall from the pedal bone. In the worst cases this results in rotation (“founder”) or sinking of the bone. The onset of laminitis may be very dramatic resulting in "acute laminitis" or develop over a period of time eventually resulting in structural changes. Laminitis is termed “chronic” when structural changes have taken place.

Figure 1: Section through the foot of a horse euthanased due to laminitis. The pedal bone is no longer parallel to the dorsal hoof wall ("rotation") and the tip of the bone is pressing down on and compressing the sole.

Figure 2: Radiograph of a horse with laminitis showing 8° of rotation between the pedal bone and the hoof wall. The dark areas mid-way between the two lines show gas between the separated laminae.

Aetiology

The laminae and their blood supply are unique in many aspects of their anatomy and physiology and are particularly susceptible to damage from a range of metabolic changes. These metabolic changes may include:

- Constriction of the blood vessels and reduced oxygen and glucose supply
- Reduction in the ability of cells to absorb glucose
- Accumulation of inflammatory cells and release of harmful inflammatory molecules
- Altered rates of cell division
- Increased activity of enzymes called matrix metalloproteinases

There are a number of potential triggers that can initiate these processes:

- Altered responses to insulin as part of Equine Metabolic Syndrome (EMS) or Pituitary Pars Intermedia Dysfunction (PPID/Equine Cushing's disease). Collectively this is termed endocrinopathic laminitis and these cases account for the majority of cases of laminitis seen in the UK. Horses with EMS often develop laminitis when turned-out and hence this may be termed "Pasture-Associated Laminitis".

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- High levels of sugar/starch in the diet that cause grain overload, damage to the large intestine and release of toxins into the blood that are carried to the feet
- Infectious diseases causing release of toxins and inflammatory products into the blood stream. For example pneumonia, uterine infections, peritonitis and colitis (diarrhoea).
- Constant work on hard surfaces causing bruising and concussion
- Constant loading of one foot causing compression of the blood vessels and increased pressure on the laminae of the other foot. This typically occurs following serious conditions such as fractures of the other limb that result in severe lameness that is present for weeks.
- Treatment with corticosteroids. Fortunately this is rare and tends to occur in horses that have other risk factors.

Clinical Signs
The signs shown depend on the severity and speed of onset of the laminitis. In acute cases horses will be unwilling to move and may choose to spend long periods lying down. Horses with laminitis often adopt a characteristic posture depending upon which feet are worst affected. In most cases (the exception being contralateral limb laminitis) all 4 feet are affected but the most severe signs are seen in the front feet because they bear the most weight. The classical laminitic stance consists of the horse leaning back to take its weight off the front feet. In rare cases when the hindlimbs are worst affected they are drawn forward under the body to transfer more weight to the forelimbs. The affected feet will be hot and the arteries to them (which can be felt over the back of the fetlocks) are usually bounding. Generally right and left limbs are affected to the same degree but occasionally one limb will be worst affected leading to preferential placement of weight on the other limb and even lifting of the affected limb off the ground. This most commonly occurs in chronic laminitis when structural changes progress at different rates. Pain will often cause an increase in heart rate and respiratory rate and there may be a notable increase in the effort of breathing.

Less severely affected animals may walk but display a pottery gait, shuffling, careful foot placement and a reluctance to turn. Horses with laminitis are often unwilling to have one foot picked up as this places increased weight on the other feet. The degree of lameness in laminitis is graded on a scale called the Obel scale. Chronic cases may have mild or severe lameness and will often have visible structural changes in their feet. These include flattening of the soles caused by the rotation or sinking of the pedal bone, uneven growth rings around the hoof that diverge toward the heel, sinking at the coronary band, widening of the white line, bruising at the white line, formation of abscesses, and in severe cases prolapse of the pedal bone through the sole.

Diagnosis
In most cases diagnosis can be made on the clinical signs alone. In mild cases radiography (x-rays) may be useful to confirm the diagnosis by showing the change in position of the pedal bone. Characteristic changes are the loss of parallel alignment and presence of an angle between the bone and the hoof wall, dropping of the pedal bone within the hoof capsule and the presence of air between the bone and hoof wall (figure 2). Radiographic assessment of the position of the pedal bone is also important in assessing the severity of laminitis and thus determining the best means of treatment and the likely outcome. It is important to consider the likely primary cause of the laminitis which in the majority of cases will be EMS or PPID. Diagnosing these conditions is an important consideration when diagnosing the laminitis.

Treatment
Treatment of laminitis is multifactorial and aimed at eliminating the primary cause of the inflammation in the feet and preventing onset or worsening of structural damage. Once the pedal bone moves within the hoof capsule the prognosis decreases and the time taken for recovery markedly increases.

Dietary restriction is often a central component in treatment for horses with EMS and similar dietary restriction tends to be instigated in all types of laminitis to prevent the condition worsening.

Drugs aimed at opening the blood vessels to the feet (vasodilators) such as acepromazine and glyceryl trinitrate are sometimes used in acute cases but it is questionable whether they make a genuine difference. The major benefit of acepromazine is its tranquilising effect which relieves distress and encourages the horse to lie down and relieve pressure on the feet.

Anti-inflammatories are central to treatment primarily as pain-killers but also because the reduction in inflammation may be beneficial. Effective pain relief is essential. Drugs such as phenylbutazone ("bute"), suxibuzone, flunixin and meloxicam are central to treatment and others such as morphine and local anaesthetics may also be used in severe cases.

In order to prevent lasting damage to the feet mechanical support is vital. Central to this is support of the pedal bone at the back half of the foot and reduction of the forces that would naturally cause separation of the bone and the hoof wall. It is generally better to remove shoes to reduce loading on the hoof wall and to apply support to the frog and/or sole which lie beneath the pedal bone. This may be done with deep bedding, foam pads, sole putty, cotton bandages or "lily pads" (figures 4-6). Different systems suit different horses. Once over the immediate phase of the disease the dorsal hoof wall is usually paired back and the heels lowered to reduce distractive forces at the toe. It is important that the horse remains confined in a very small area until sound. Whilst the laminae are inflamed and the pedal bone is unstable movement will increase the chances of the pedal bone displacing. Traditional theories about forcing horses with laminitis to walk when they have laminitis are not only misguided but exceedingly cruel.

When movement of the pedal bone has occurred (i.e. chronic laminitis) corrective farriery is the best means of restoring the normal function of the foot.
There are a number of shoeing systems designed or well suited for laminitics all of which aim to shift the point of break-over back to the centre of the foot. Heart bars, plastic shoes, clogs and the equine digital support system are all potential options. There is no one system that is superior; different vets or farriers have personal preferences and some horses do better in certain systems than others. There is often an element of trial and error. More radical treatments include removal of the dorsal hoof wall and cutting of the flexor tendons but these procedures are controversial.

Disease Control and Prevention

Laminitis is prevented by aggressively treating the conditions that lead to it. In the majority of cases this is by effective management of EMS and PPID. Dietary restriction is central to the management of horses with EMS; PPID is effectively controlled in most cases with pergolide. The risk of contralateral limb laminitis is reduced by aggressive treatment of the lameness in the other limb combined with effective analgesia and application of foot supports to the limb at risk of laminitis. "Grain overload" is often treated with laxatives and the administration of anti-inflammatories and other drugs that aim to prevent the development of disease in the feet; unfortunately there is little evidence that these are effective.

For horses known to be at immediate risk of laminitis cryotherapy (cooling the feet) is effective. To be effective the lower limbs need to be bathed in ice which is frequently impractical. Furthermore, in the majority of cases the window in which cryotherapy is likely to be effective has passed before the laminitis is identified.

Although it is often difficult to act before acute laminitis develops there is often an opportunity to prevent structural changes in the feet after the onset of disease. If structural changes occur then recovery will take far longer and the risk of recurrence and permanent lameness will be higher. In this phase of the disease it is important to be cruel to be kind and to limit movement whilst providing effective analgesia and mechanical support. This is often required for weeks and should be managed under veterinary supervision. Too often horses are neither confined nor supported for long enough increasing the risk of long-term, and sometimes irreparable, damage.

Summary of Key Learning Points

- Laminitis is a common reason for euthanasia of horses in the UK and a major cause of pain and suffering
- Laminitis is inflammation of the tissues in the feet that hold the bone within the hoof capsule
- The majority of cases are a consequence of dietary excess, EMS and PPID
- There are numerous other potential causes because horses’ feet are uniquely susceptible to damage following a range of diseases elsewhere in the body
- Affected horses are reluctant to move, may adopt a characteristic stance and may have hot feet with a bounding digital pulse
- X-rays are helpful for diagnosis and for guiding treatment
- The mainstays of treatment are pain-relief and mechanical support
- Many other drugs may be indicated in specific circumstances aimed at specific disease processes
- It is essential that horses have their feet supported and movement restricted in order to prevent long-term damage
- Corrective farriery is important in the long-term management of chronic cases

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